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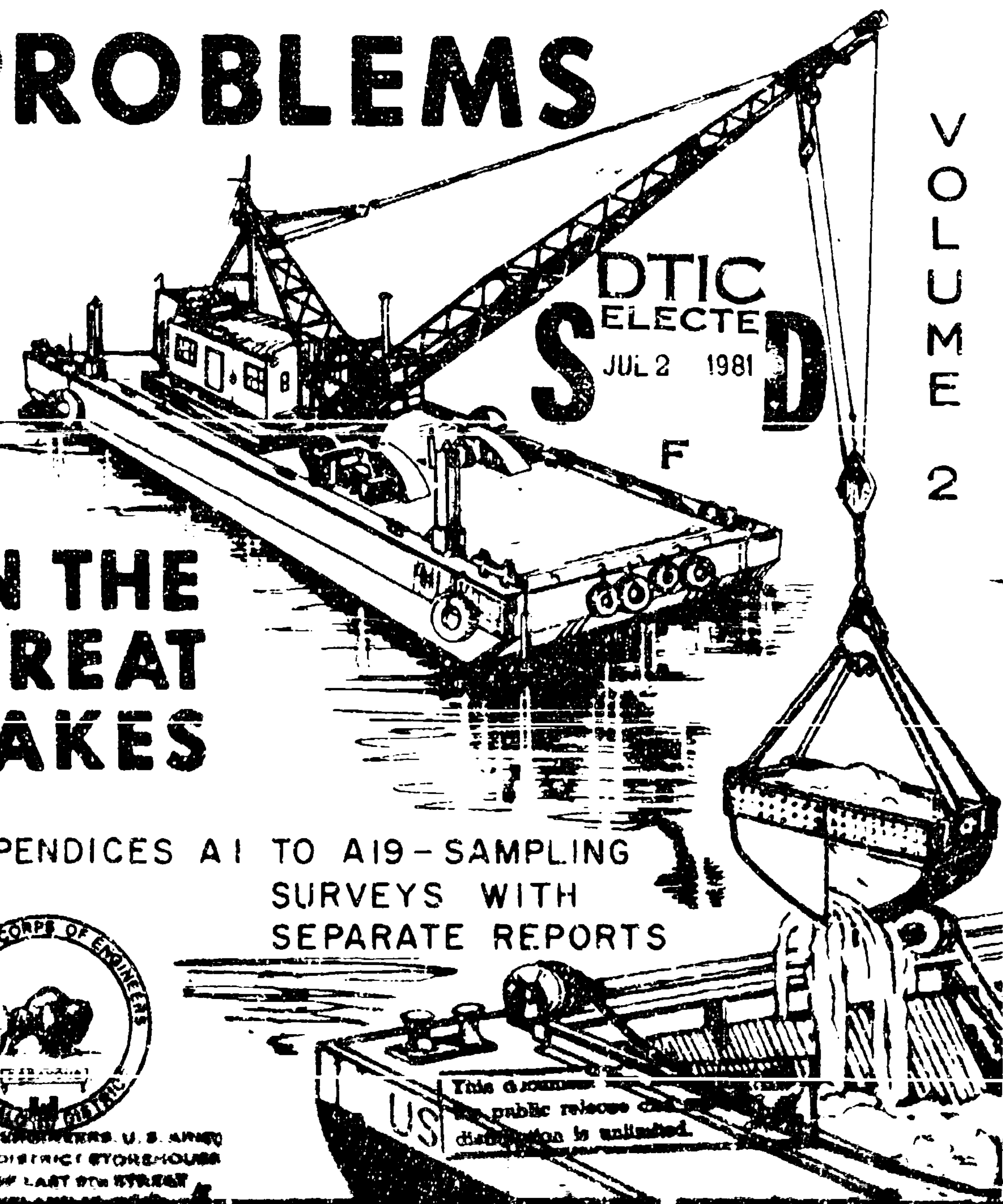
DREDGING WATER QUALITY PROBLEMS

IN THE GREAT LAKES

VOLUME 2



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APPENDICES A1 TO A19 – SAMPLING SURVEYS WITH SEPARATE REPORTS

U.S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT

CORPS OF ENGINEERS, U.S. ARMY
BUFFALO DISTRICT STOREHOUSE
FOOT OF EAST 9th STREET

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The present report presents the results of a study conducted by the Corps of Engineers with cooperation of the Federal Water Pollution Control Administration to evaluate the effects of water quality of current dredging practices including the disposal of dredged material in unconfined open water areas of the Great Lakes, as well as to develop the most practical methods for management of pollution problems that may be identified as resulting from dredging operations on the Lakes. The investigations conducted during the study included contruction and operation of diked areas, treatment

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE 410090

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) of the dredged material, modifications to dredge equipment and in dredging operations, functional studies of the effects on lake ecology of open-lake disposal, surveys of possible alterate disposal areas at 37 Great Lakes harbors and connecting channels, and an economic evaluation of benefits which might accrue from improved Great Lakes water quality.

Appendix A

SAMPLING SURVEYS WITH SEPARATE REPORTS

Most of the sampling surveys conducted for the present study were concentrated at the eight pilot areas. However, a number of other navigation projects were sampled in as much detail as time and resources permitted. This appendix is an inventory of the sampling surveys, made during the course of the present study, for which separate reports were prepared for individual projects.

Inventory of Sampling Surveys With Separate Report

Project	Year	Sampling Agency[a]	Appendix No.
Lake Superior:			
None with a separate report			
Lake Michigan:			
Calumet River and Harbor,	1967	FWPCA	A8
Illinois and Indiana	1968	FWPCA	n/a
Frankfort Harbor, Michigan	1967	LS	A24
Green Bay Harbor, Wisconsin	1967	FWPCA	A9
	1968	FWPCA	A13
Indiana Harbor, Indiana	1967	FWPCA	A7
	1967	LS	A25
Kenosha Harbor, Wisconsin	1968	FWPCA	A15
Manistee Harbor, Michigan	1967	LS	A22
Manitowac Harbor, Wisconsin	1968	FWPCA	A18
Milwaukee Harbor, Wisconsin	1968	FWPCA	A16
New Buffalo Harbor, Michigan	1968	FWPCA	A10
Oconto Harbor, Wisconsin	1968	FWPCA	A11
Pensaukee Harbor, Wisconsin	1968	FWPCA	A12
Port Washington Harbor, Wisconsin	1968	FWPCA	A17
Two Rivers, Michigan	1968	FWPCA	A19
Waukegan Harbor, Illinois	1968	FWPCA	A14
Lake Huron and Connecting Channels:			
Alpena Harbor, Michigan	1967	LS	A23
Au Sable Harbor, Michigan	1967	LS	A20
Rouge River, Michigan	1967	FWPCA	A6
Lake Erie:			
Ashtabula Harbor, Ohio	1967	LS	A26
Buffalo Harbor, Black Rock Channel and Tonawanda Harbor, New York	1967	FWPCA	A3

Table Cont.

Project	Year	Sampling Agency[a]	Appendix No.
Cleveland Harbor, Ohio	1967	FWPCA	A4
	1967	LS	A29
	1968	FWPCA	A5
Erie Harbor, Pennsylvania	1967	LS	A28
Lorain Harbor, Ohio	1967	LS	A30
Sandusky Harbor, Ohio	1967	LS	A21
Toledo Harbor, Ohio	1967	LS	A27
Lake Ontario:			
Great Sodus Bay Harbor, New York	1967	FWPCA	A1
	1968	FWPCA	A2

a - Agency abbreviations: FWPCA - Federal Water Pollution Control Administration; LS - U. S. Lake Survey District

n/a - Not available

APPENDIX A I

PILOT STUDY

Summer 1967

GREAT SODUS BAY

DISPOSAL OF DREDGINGS

U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Great Lakes Region
Rochester Program Office
Rochester, New York

January 1968

U. S. DEPARTMENT OF INTERIOR
Federal Water Pollution Control Administration
Great Lakes Region
Rochester Program Office
Rochester, New York

GREAT SODUS BAY DREDGING INVESTIGATION

Summer 1967

Introduction

The following information pertains to predredged samples collected at individual stations from a small boat and composit samples from the Corp of Engineer's dredge Markham as it plied the full length of the channel being dredged. The post-dredge sample at the dumping ground was also an individual sample.

Predredge Samples

Predredge mud samples were collected by means of a Peterson dredge. The water samples were collected by means of an APHA DO sampler just above the bottom. Predredge samples were collected as follows:

	Station	Date
Mud	164	4-21-67
Water	164	4-21-67
Mud	9, 10, 11, 12	5-16-67
Water	9, 10, 11, 12	5-16-67
Mud	7, 8, 166	5-18-67
Water	7, 8, 166	5-18-67

Markham Samples

Dredged samples were collected at the intakes to the hoppers and the overflow from the Corp of Engineer's dredge Markham. The samples were collected as the dredge proceeded up and down the channel. Dredged samples were collected as follows:

	Stations	Dates
Intake	7 thru 11	5-23-67
Overflow	7 thru 11	5-28-67
Composite*	7 thru 11	5-23-67
Intake	7 thru 11	5-25-67
Overflow	7 thru 11	5-25-67
Intake	7 thru 11	5-26-67
Overflow	7 thru 11	5-26-67

* The composite sample consisted of two intake samples that were composited. The supernatant was considered as water and the residue remaining as mud.

Post-dredging

One sample of mud using a Peterson dredge and one of water by means of a PVC sampler were collected at Station 166 (dumping ground) on 10-17-67 from the Coast Guard Tug Objibwa.

Analysis and Data

Figures 1 to 11, that follow, give a graphical display of some of the chemical data obtained from the examination of the mud and water. The graphical information is presented as follows:

Figure	Parameter
1	pH
2	Conductivity
3	COD
4	Phosphates - Total
5	- Dissolved
6	Nitrogen - Total
7	- Nitrates
8	Solids - Total
9	- Dissolved
10	- Volitle, Total
11	Oxidation - Reduction Potential

The analysis procedures as carried out at the Rochester Program Office are attached, see Appendix "A".

Comments relative to some of the parameters are as follows:

GREAT SODUS BAY DREDGING STUDY

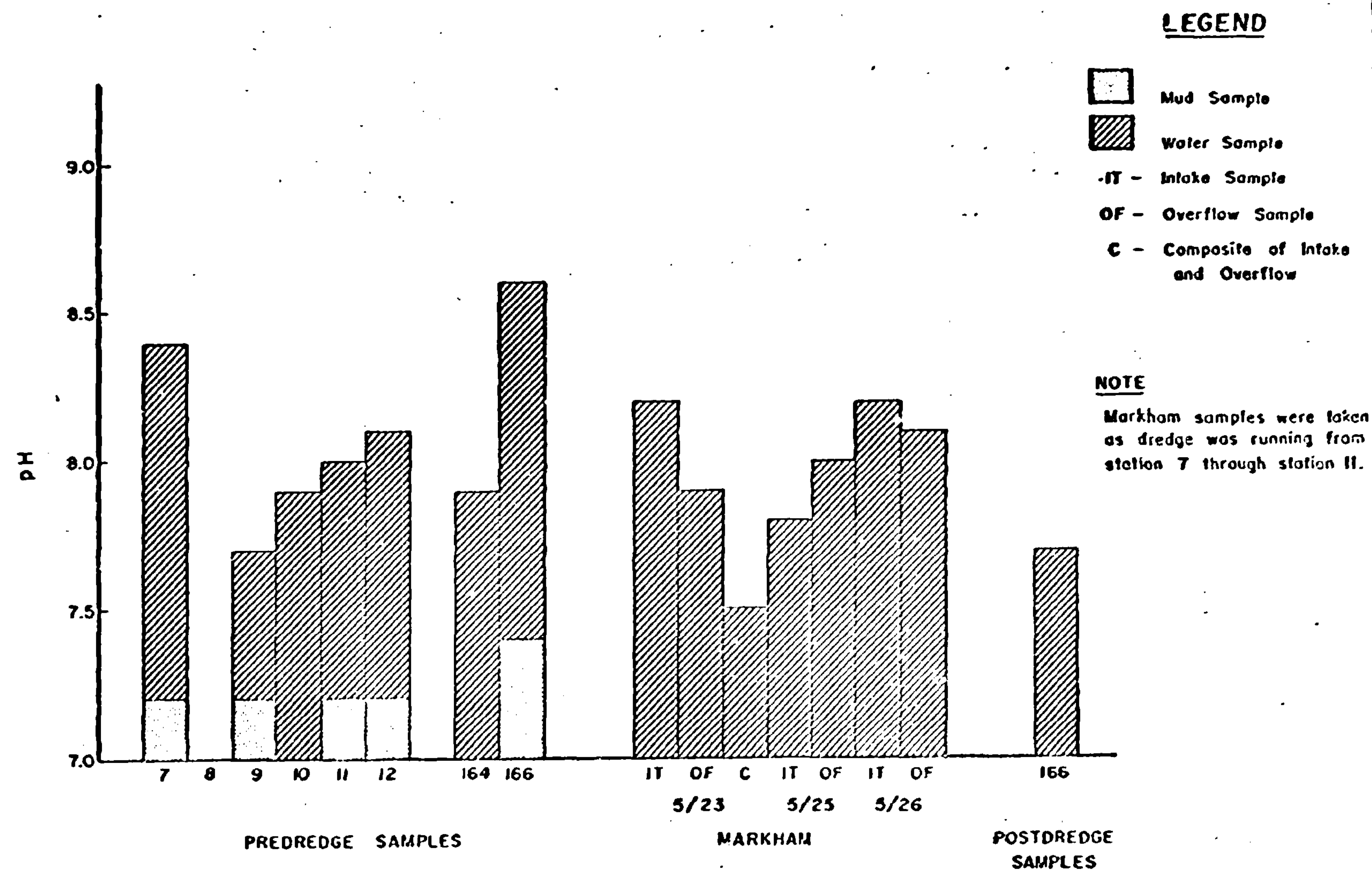
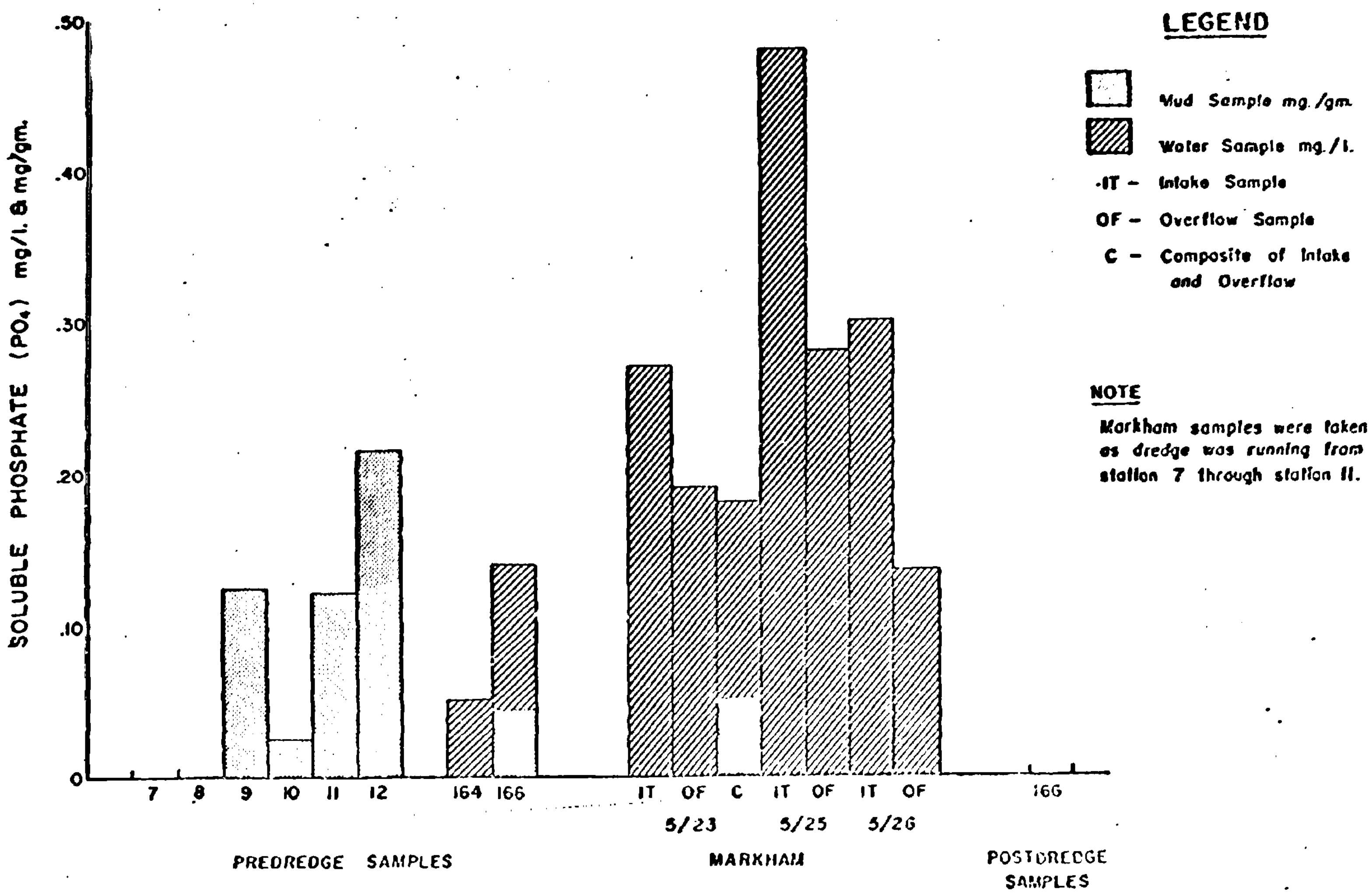


FIGURE 1

GREAT SODUS BAY DREDGING STUDY



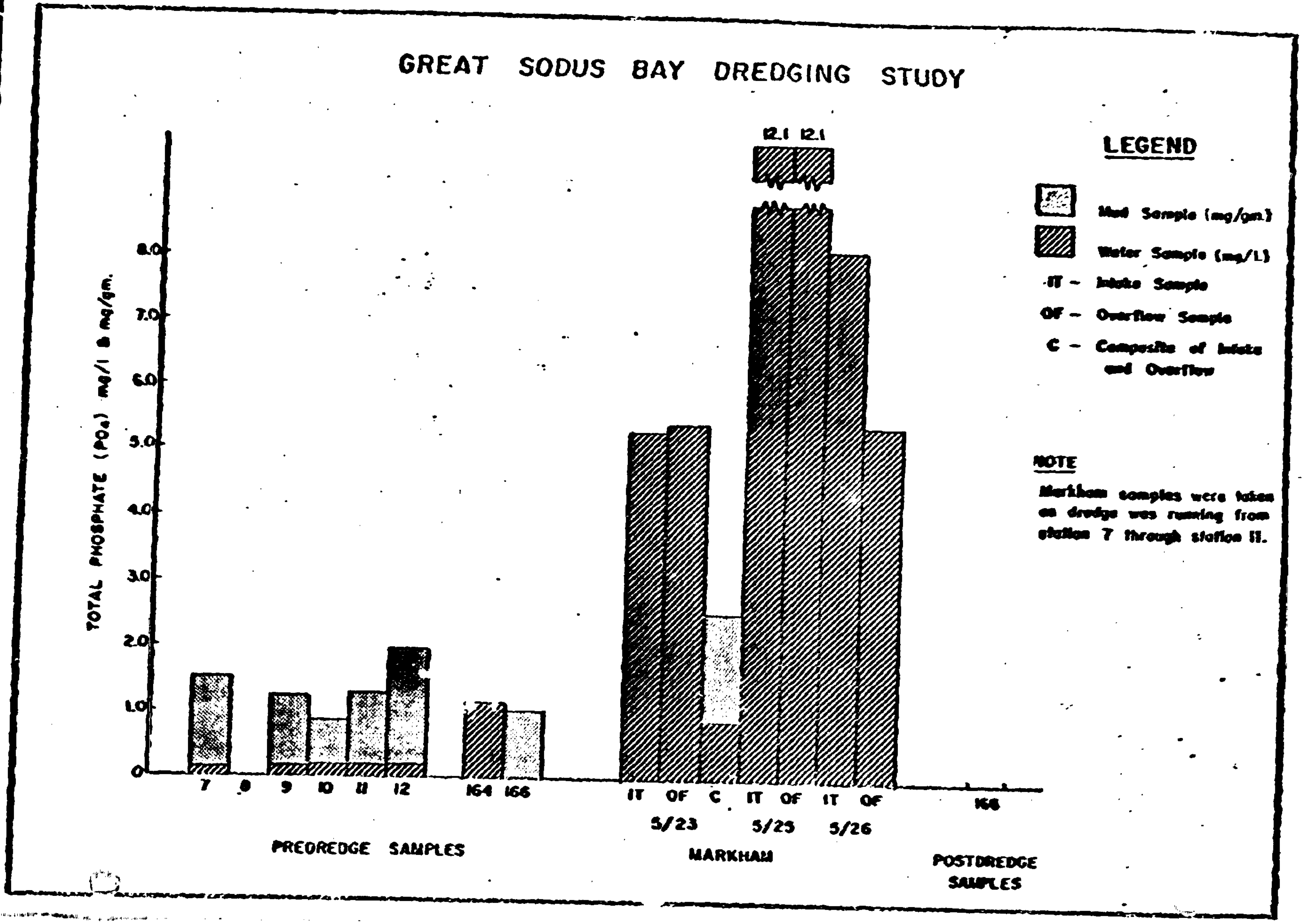
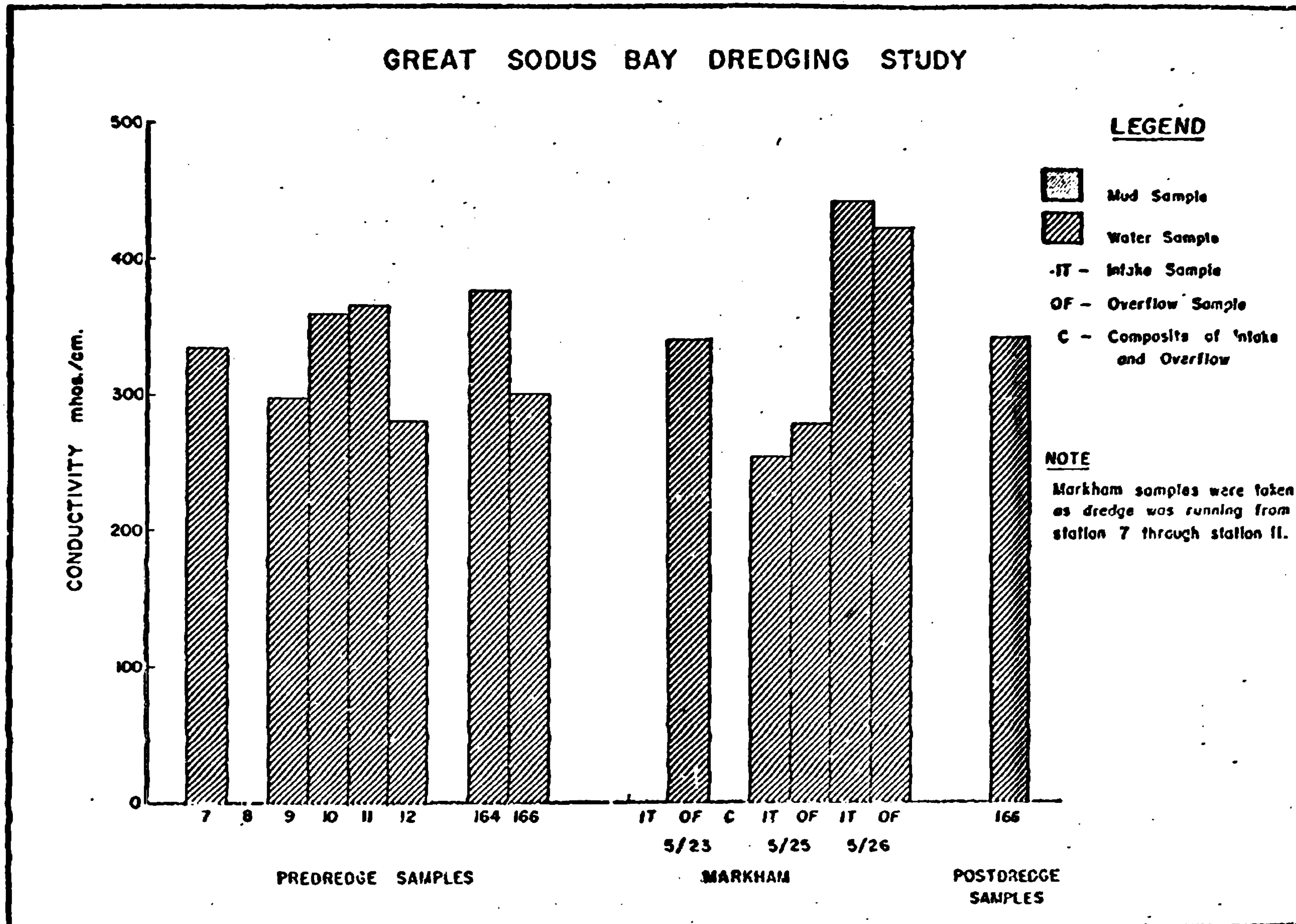

GREAT SODUS BAY DREDGING STUDY
TOTAL PHOSPHATE (PO4) mg/l & mg/gm.
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7
8
9
10
11
12
164
166
PREDREDGE SAMPLES
12.1
12.1
IT
OF
C
IT
OF
IT
OF
5/23
5/25
5/26
MARKHAM
166
POSTDREDGE SAMPLES
LEGEND
Mud Sample (mg/gm)
Water Sample (mg/L)
IT – Intake Sample
OF – Overflow Sample
C – Composite of Intake and Overflow
NOTE
Markham samples were taken as dredge was running from station 7 through station 11.

FIGURE 4



GREAT SODUS BAY DREDGING STUDY
CONDUCTIVITY mhos./cm.
500
400
300
200
100
0
7
8
9
10
11
12
164
166
IT
OF
C
IT
OF
IT
OF
5/23
5/25
5/26
PREDREDGE SAMPLES
MARKHAM
166
POSTDREDGE SAMPLES
LEGEND
Mud Sample
Water Sample
IT - Intake Sample
OF - Overflow Sample
C - Composite of Intake and Overflow
NOTE
Markham samples were taken as dredge was running from station 7 through station 11.

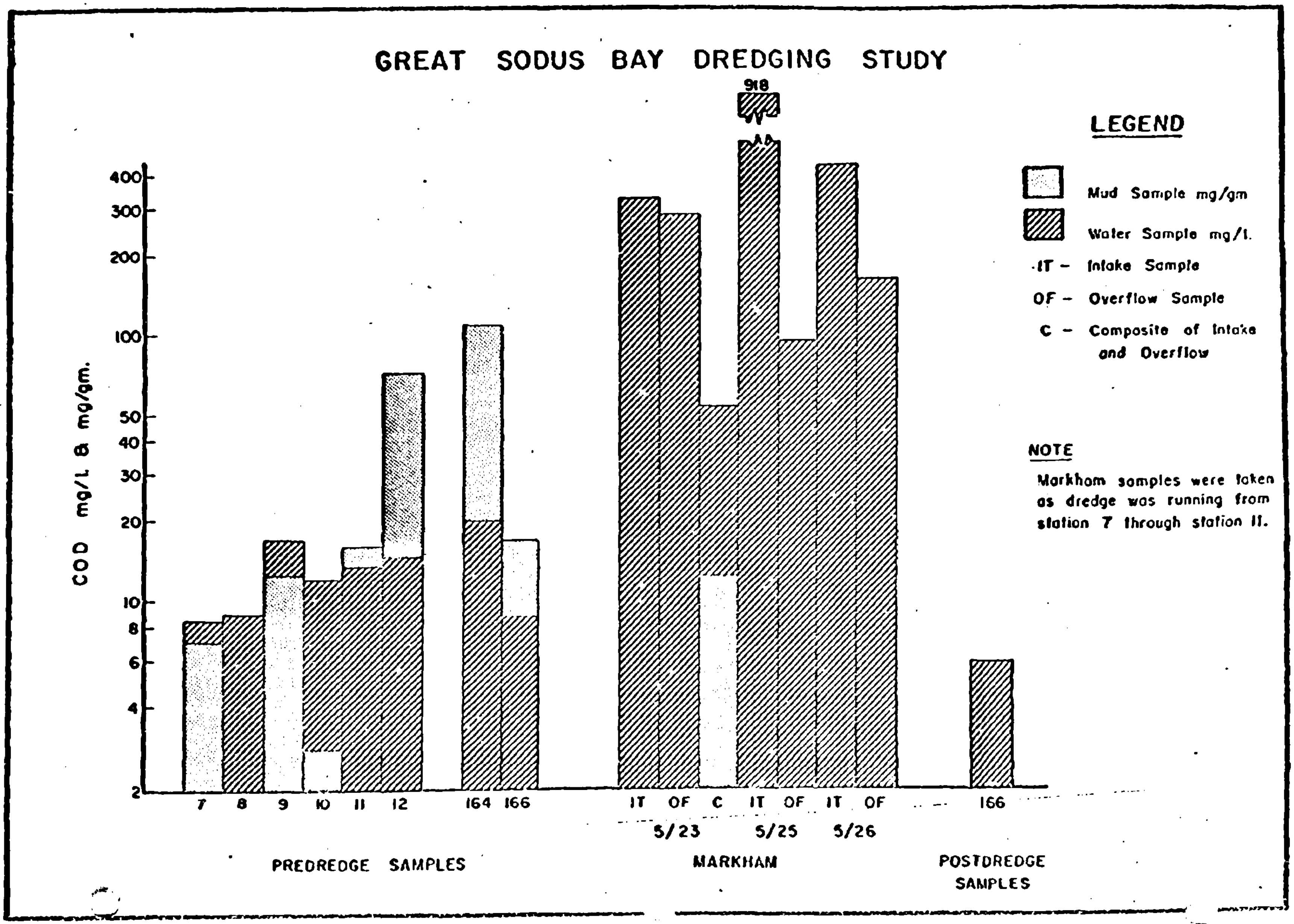

GREAT SODUS BAY DREDGING STUDY
918
COD mg/L & mg/gm.
400
300
200
100
50
40
30
20
10
8
6
4
2
7 8 9 10 11 12 164 166
PREDREDGE SAMPLES
IT OF C IT OF IT OF
5/23 5/25 5/26
MARKHAM
166
POSTDREDGE SAMPLES
LEGEND
Mud Sample mg/gm
Water Sample mg/l.
IT - Intake Sample
OF - Overflow Sample
C - Composite of Intake and Overflow
NOTE
Markham samples were taken as dredge was running from station 7 through station 11.

FIGURE 5

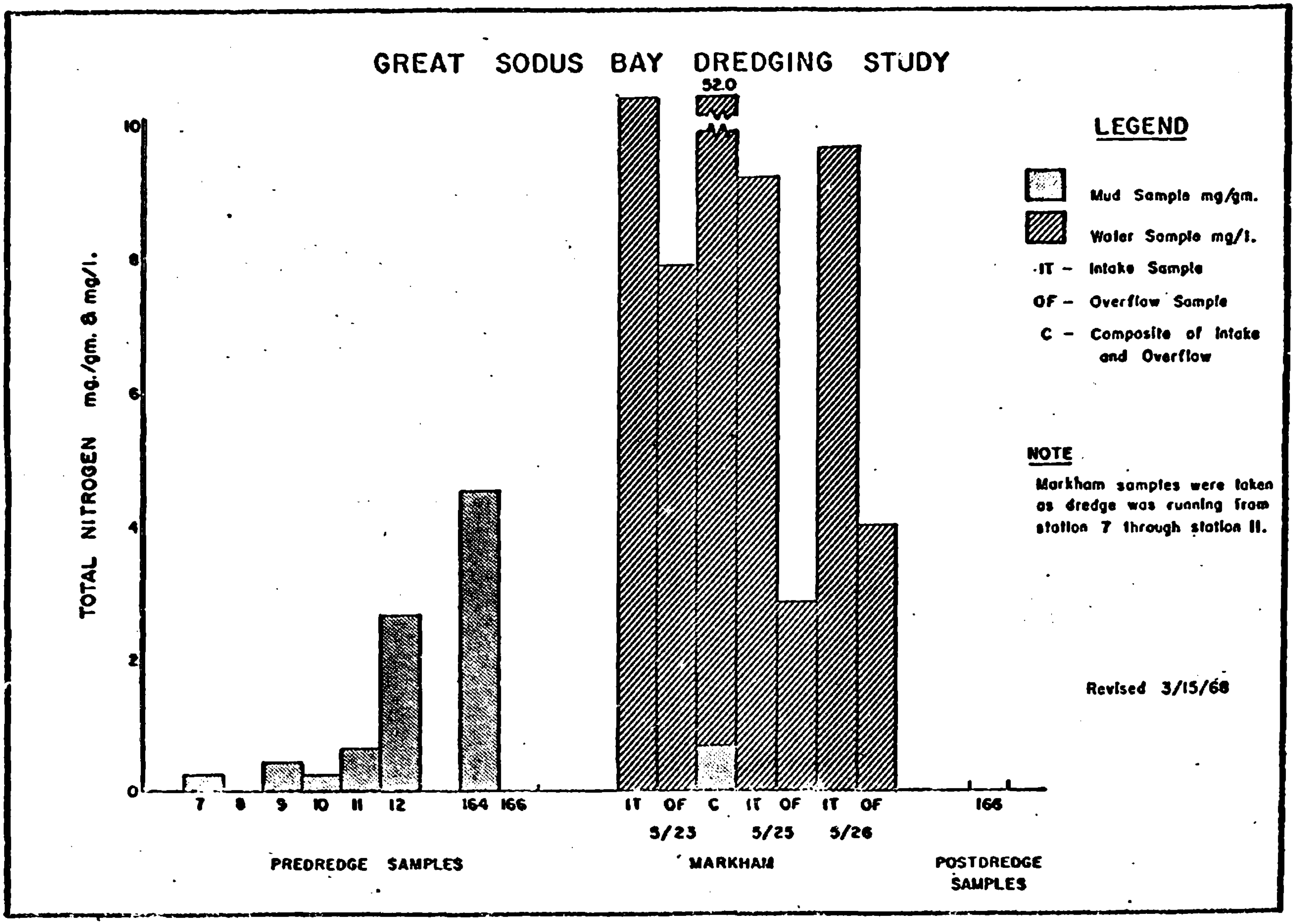

GREAT SODUS BAY DREDGING STUDY
TOTAL NITROGEN mg./gm. & mg/l.
0
2
4
6
8
10
52.0
7
8
9
10
11
12
164
166
IT
OF
C
IT
OF
IT
OF
5/23
5/25
5/26
166
PREDREDGE SAMPLES
MARKHAM
POSTDREDGE SAMPLES
LEGEND
Mud Sample mg/gm.
Water Sample mg/l.
IT – Intake Sample
OF – Overflow Sample
C – Composite of Intake and Overflow
NOTE
Markham samples were taken as dredge was running from station 7 through station 11.
Revised 3/15/68

FIGURE 6

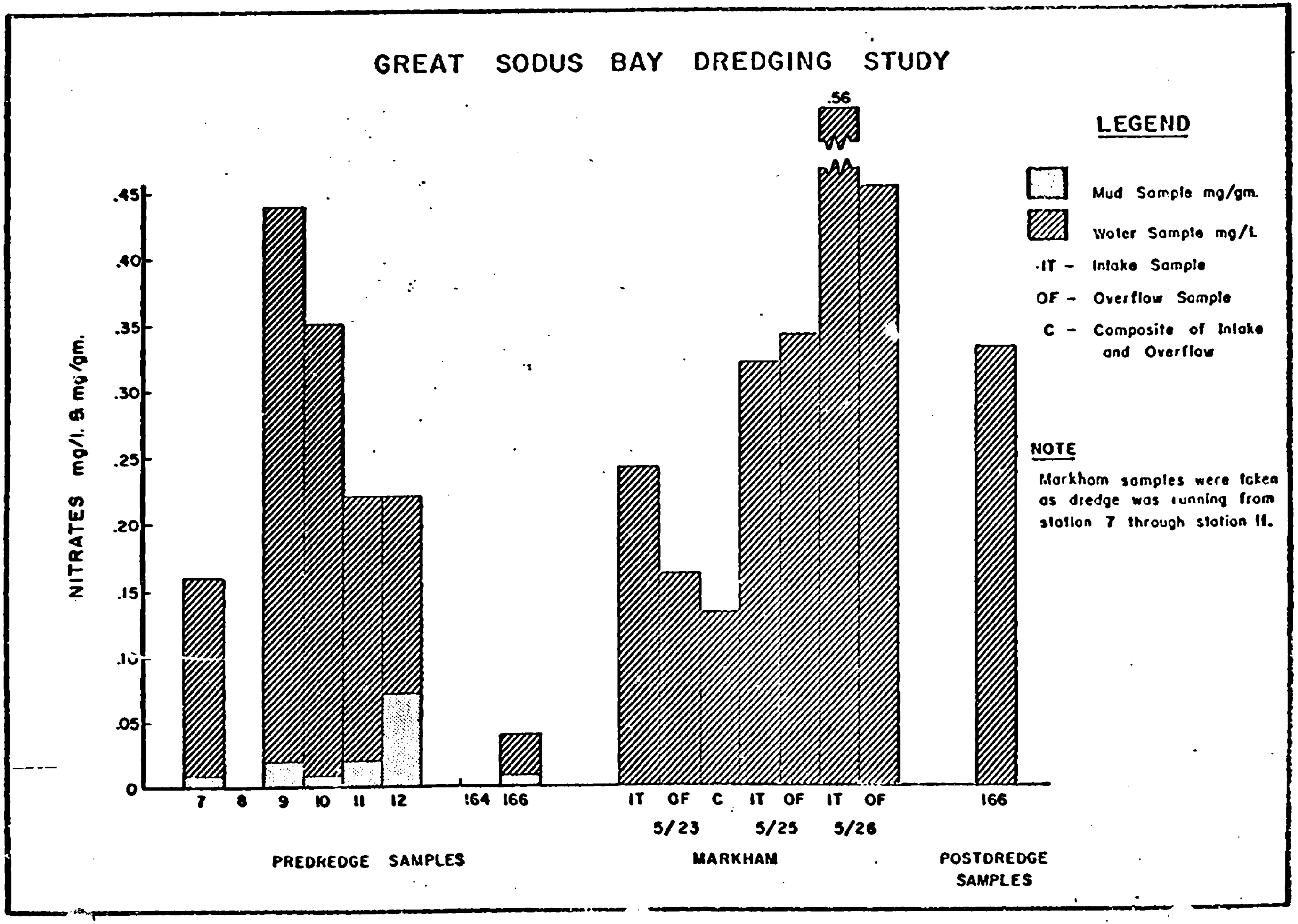

GREAT SODUS BAY DREDGING STUDY
.56
LEGEND
Mud Sample mg/gm.
Water Sample mg/L
IT - Intake Sample
OF - Overflow Sample
C - Composite of Intake and Overflow
NOTE
Markham samples were taken as dredge was running from station 7 through station 11.
NITRATES mg/l. & mg/gm.
.45
.40
.35
.30
.25
.20
.15
.10
.05
0
7
8
9
10
11
12
164
166
IT
OF
C
IT
OF
IT
OF
5/23
5/25
5/26
166
PREDREDGE SAMPLES
MARKHAM
POSTDREDGE SAMPLES

FIGURE 7

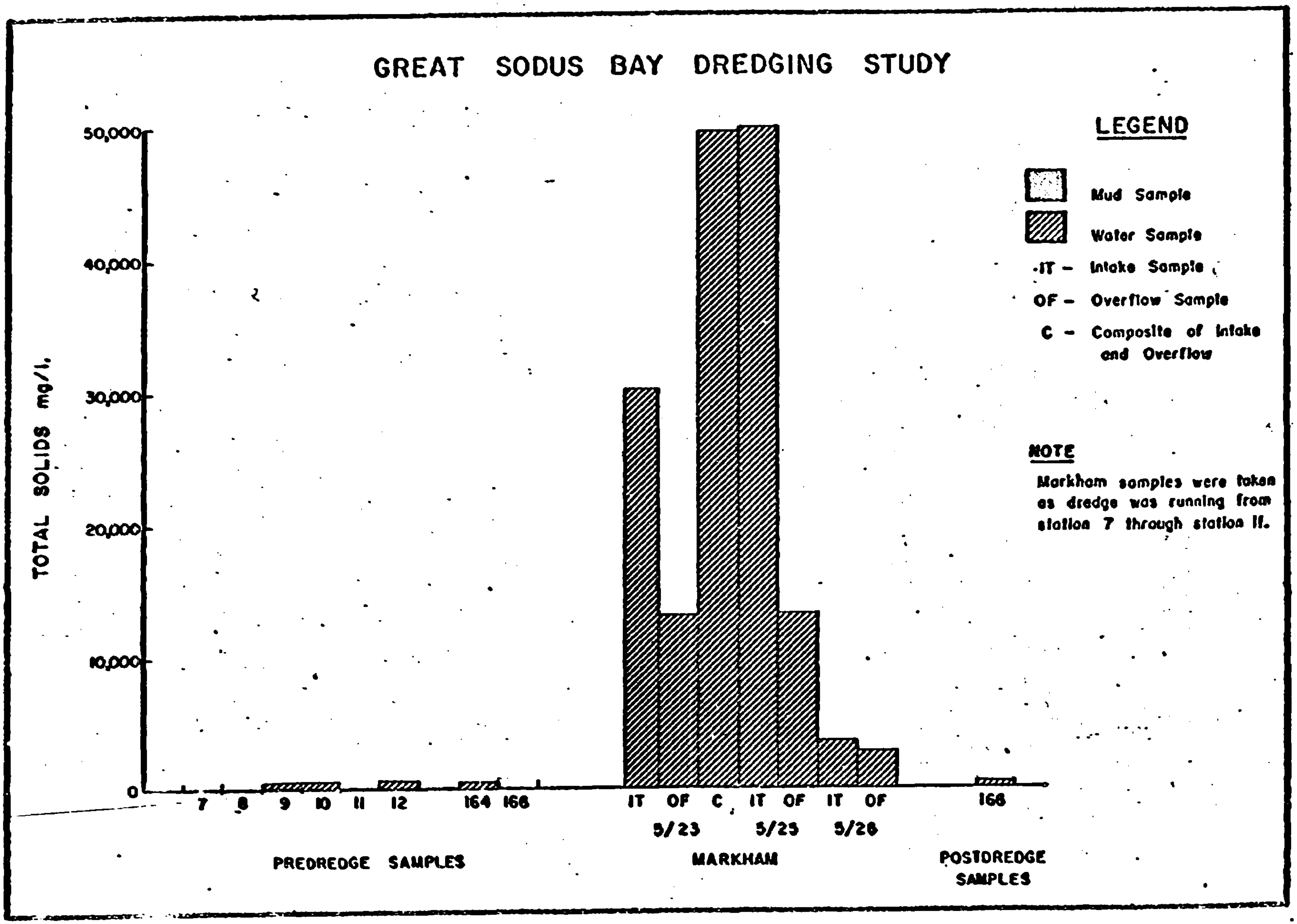

GREAT SODUS BAY DREDGING STUDY
TOTAL SOLIDS mg/l.
50,000
40,000
30,000
20,000
10,000
0
7 8 9 10 11 12 164 166
PREDREDGE SAMPLES
IT OF C IT OF IT OF
5/23 5/25 5/26
MARKHAM
168
POSTDREDGE SAMPLES
LEGEND
Mud Sample
Water Sample
IT - Intake Sample
OF - Overflow Sample
C - Composite of Intake and Overflow
NOTE
Markham samples were taken as dredge was running from station 7 through station 11.

FIGURE 8

GREAT SODUS BAY DREDGING STUDY

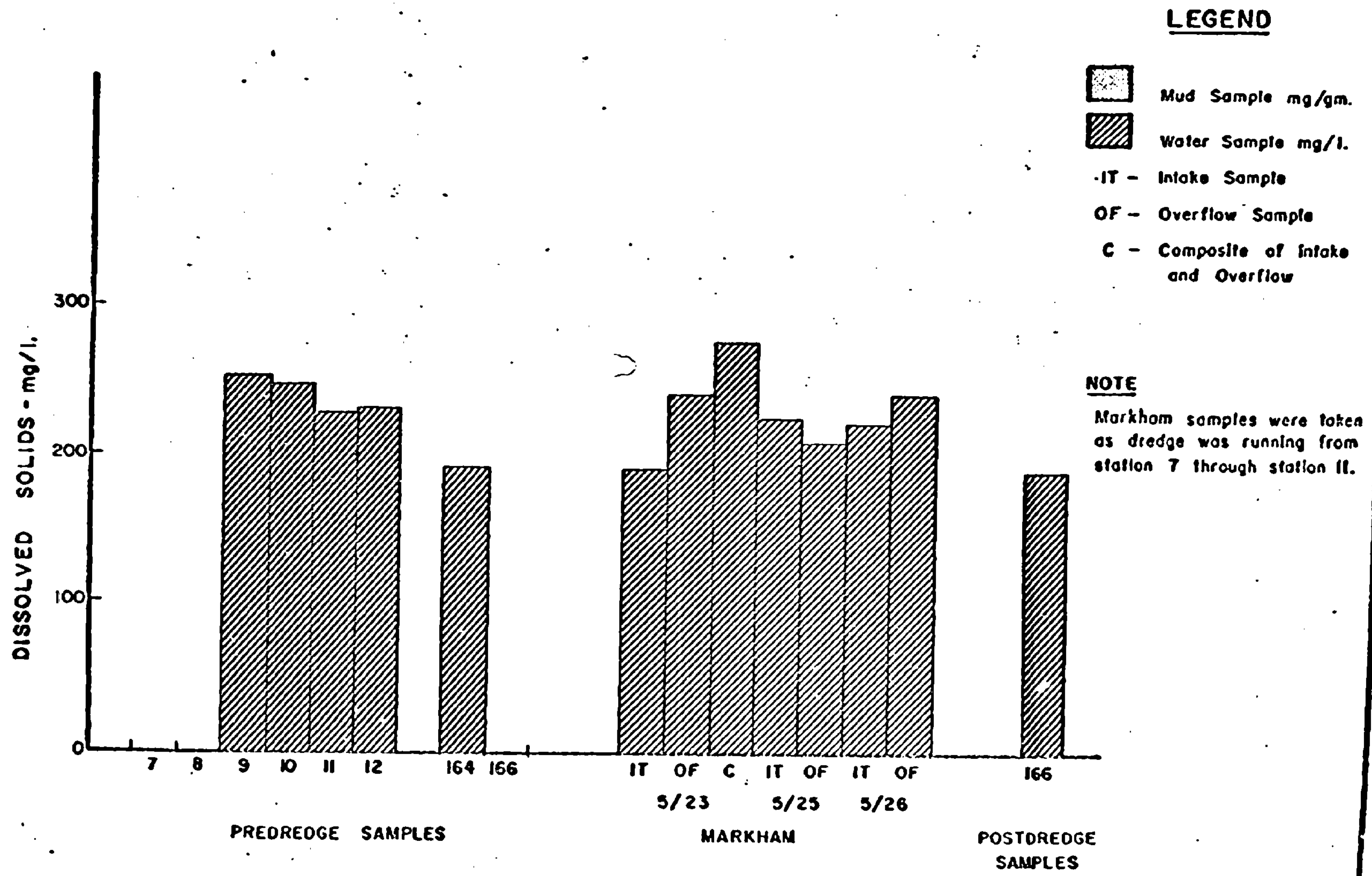


FIGURE 9

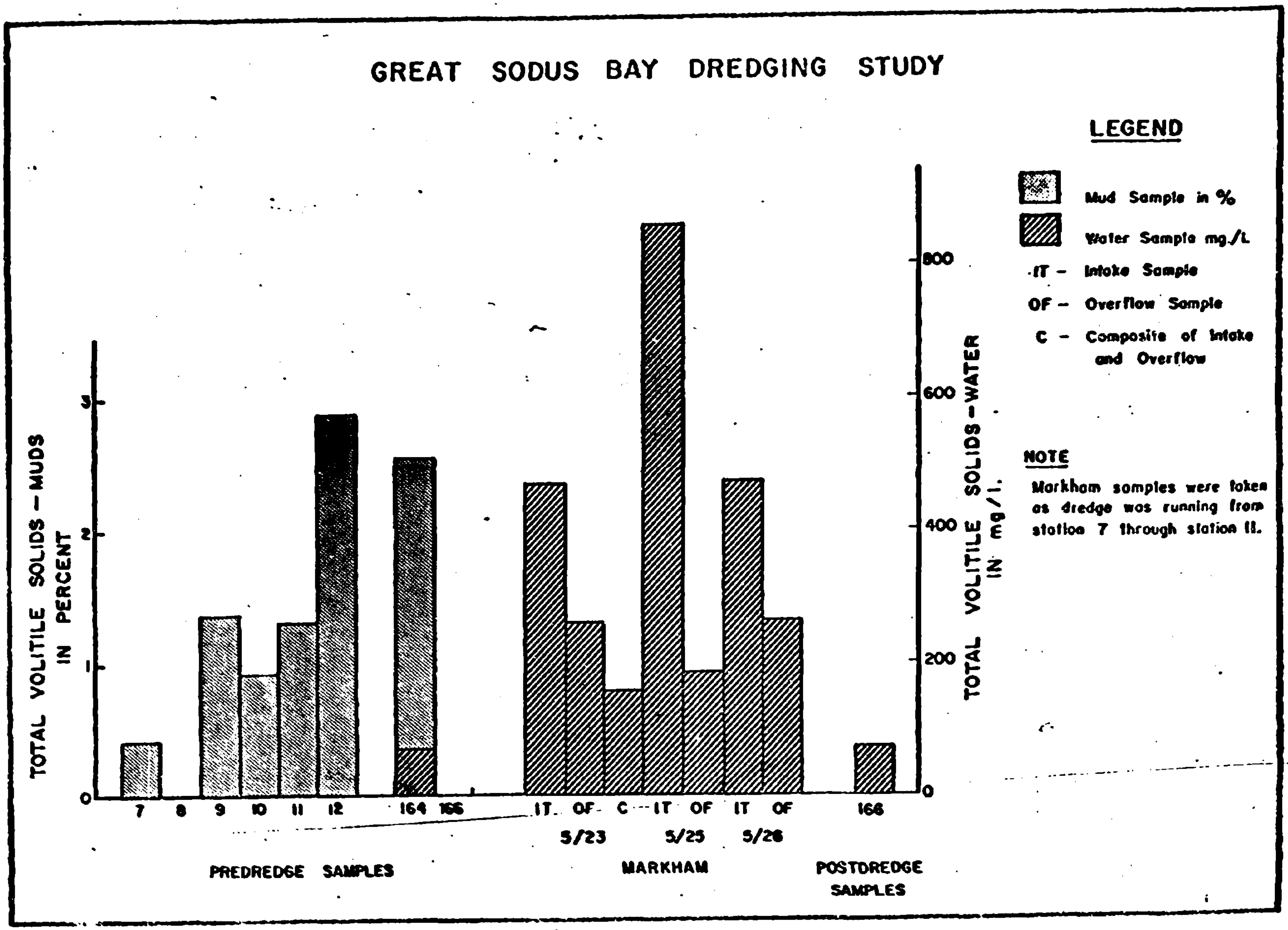
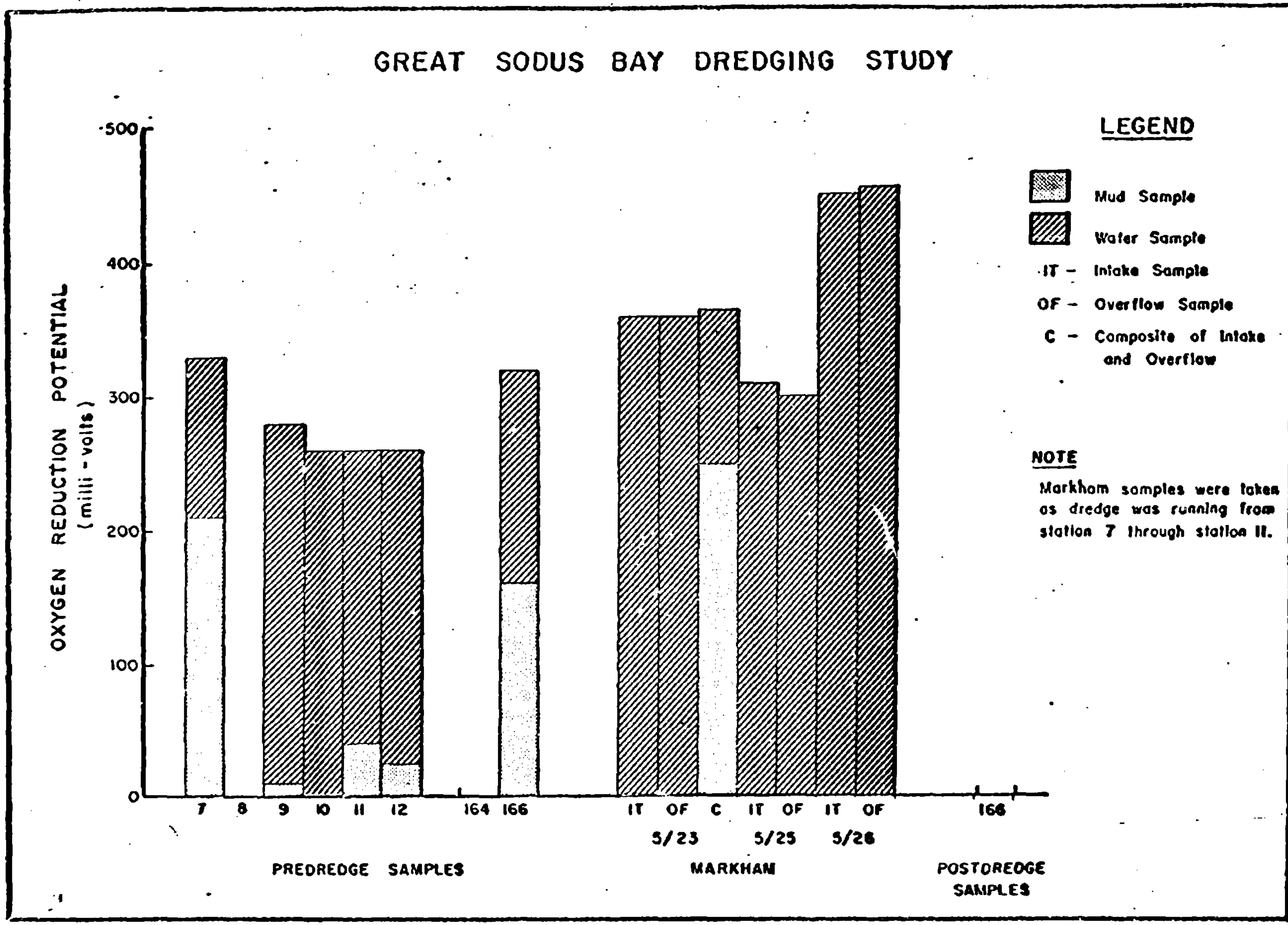

GREAT SODUS BAY DREDGING STUDY
LEGEND
Mud Sample in %
Water Sample mg./L
IT - Intake Sample
OF - Overflow Sample
C - Composite of Intake and Overflow
NOTE
Markham samples were taken as dredge was running from station 7 through station 11.
TOTAL VOLITILE SOLIDS - MUDS IN PERCENT
TOTAL VOLITILE SOLIDS - WATER IN mg/l.
0
1
2
3
200
400
600
800
7
8
9
10
11
12
164
166
IT
OF
C
IT
OF
IT
OF
5/23
5/25
5/26
166
PREDREDGE SAMPLES
MARKHAM
POSTDREDGE SAMPLES

FIGURE 10



GREAT SODUS BAY DREDGING STUDY
OXYGEN REDUCTION POTENTIAL
(milli - volts)
0
100
200
300
400
500
7
8
9
10
11
12
164
166
IT
OF
C
IT
OF
IT
OF
5/23
5/25
5/26
168
PREDREDGE SAMPLES
MARKHAM
POSTDREDGE SAMPLES
LEGEND
Mud Sample
Water Sample
IT - Intake Sample
OF - Overflow Sample
C - Composite of Intake and Overflow
NOTE
Markham samples were taken as dredge was running from station 7 through station II.

FIGURE 11

Figure	Parameter	Comment
1	pH	The water sample from Station 7 of the predredge samples because of its location could very well be influenced by the lake (166) water pH rather than the water flowing from the harbor. However, there is no explanation for the great difference between the spring and fall pH at Station 166 unless the spring blooms were a factor.
3	COD	It is quite obvious when the muds are mixed with water as on the Markham they impart a high COD to the sample water. That individual samples taken during predredging do not reflect the conditions to be expected from the mixing caused by the dredging operation. The results also show the excessive COD loading imparted to the receiving waters while the dredge is in operation via the overflow discharge.
4	Phosphate, Total	As in the explanation of the COD above, the phosphates also are present in the muds in greater amounts than in the water. The dredging operation for short periods apparently upsets the water/mud ratio of phosphates in that the liquid overflow and the liquid eventually discharged to the dumping ground contains considerable more phosphates than the overlying waters. Settlement and dispersion would soon return the mud/water phosphate ratio back to normal. However, the amount of phosphate being moved about may be adequate to promote algae growth in previously phosphate poor water.
5	Phosphate, Dissolved	The only comment is that it appears that settling of the sediment in the hoppers has through physical or mechanical absorption caused the soluable phosphate to be reduced or returned to the muds. Upon dumping, some of the phosphate could again separate from the sediment and be carried about by currents.

Figure	Parameter	Comment
8	Total Solids	It is quite evident dredging does increase the total solids of the waters being dredged. While the graphical display does not give information on water over the dredged or dumping area at the time of dredging, dumping photographs of other dredging operations show considerable amounts of solids in the water. Settlement and dispersion, however, in a matter of hours removes the visible solids.

Chemical data for each station is displayed in Table 1. With known amounts of dredged material the amount of BOD, COD, phosphates, etc. removed from the channel and deposited in the lake could be estimated.

Benthic Biology

Predredge mud samples provided little information as to Benthic life because of the samples collected. However, the only organisms found were tubificid worms.

Station No.	Number Tubificid Worms
7	2
9	1
10	2
11	1
12	6
166	4

As only a 100 ml sample of mud was provided for the biologist, the only conclusion reached is that pollution - tolerant organisms lived in the area sampled.

A post-dredge sample collected at Station 166 in October 1967 under the biologist's direction provided the following information:

Tubificidae	575/sq. meter
Pontoporea (scuds)	113 sq. meter
Tendipedidae	25/sq. meter

Table I

ROCHESTER PROGRAM OFFICE
Great Sodus Bay Dredging Study
Chemical Data

Predredged Information 1967

Date	4/21	4/21	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16		
Sta. No.	164	164	9	10	11	12	9	10	11	12		
Depth (m)	Mud	H_2O	Mud	Mud	Mud	Mud	H_2O	H_2O	H_2O	H_2O		
Parameters, °C												
pH	.	7.9	7.2		7.2	7.2	7.7	7.9	8.0	8.1		
Spec. Cond.		375					298	360	364	280		
alkalinity		100					104	102	102	102		
turbidity		175					5.0	4.3	5.0	4.4		
DO												
BOD		1.6										
COD	110	20	12.4	2.8	15.9	72.7	17.0	12.0	13.4	14.4		
N-Tot. Kje.	4.5		.47	124	.64	2.68						
$N-NO_3$			.02	.01	.02	.07	.44	.35	.22	.22		
N-Org.												
PO_4-Tot.		.15	1.23	.84	1.27	1.97	.13	.16	.16	.16		
-Sol.		.05	.125	.025	.123	.214	.043					
Solids-Diss.		191					252	247	227	230		
-Susp.		9					9	44	191	46		
-Tot.		200					261	272	418	276		
- Vol. T.	2.6%	72	1.37	.93	1.32	2.88						
Cl.		24					24	24	25	25		
SiO_2	88%		87	92	90	81						
Ca		64										
EH(mv)			10		40	25	270	260	260	260		
Fe	1.8		3.4	3.7	3.3	2.4						

Table I (cont'd)

ROCHESTER PROGRAM OFFICE
Great Sodus Bay Dredging Study
Chemical Data

Predredging Information (cont'd) 1967

Date	5/18	5/18	5/18	5/18	5/18	5/18						
Sta., No.	7	7	8	8	166	166						
Depth (m)	Mud	H_2O	Mud	H_2O	Mud	H_2O						
Parameters, °C												
pH	7.2	8.4			7.4	8.6						
Spec. Cond.		334				300						
alkalinity												
turbidity												
DO												
BOD												
COD	7.1	8.5		9.0		8.2						
N-Tot. Kje.	.27											
$N-NO_3$	.01	.16			.01	.04						
N-Org.												
PO_4-Tot.	1.5	.11			1.0							
-Sol.	.01				.043	.135						
Solids-Diss.												
-Susp.												
-Tot.												
- Vol. T.	.42%											
Cl. -												
SiO_2	68.7											
~~XXX~~ EH (MV)	210	330			160	320						
EH(mv)												
Fe	5.73											

Table I (cont'd)

ROCHESTER PROGRAM OFFICE
Great Sodus Bay Dredging Study
Chemical Data

Markham Operation - 1967

Date	5/23	5/23	5/23	5/23		5/25	5/25		5/26	5/26		
Sta., No.	IN	OF	C-W	C-M		IN	OF		IN	Of		
Depth (m)												
Parameters, °C												
pH	8.2*	7.9*	7.5*			7.8*	8.0*		8.2*	8.1*		
Spec. Cond.		340				252	276		440	420		
alkalinity	117	118										
turbidity												
DO												
BOD												
COD	340	290	54			918	95		440	167		
N- Tot. Kje.	10.4	7.9	52	.63		9.15	2.8		9.6	3.9		
$N-NO_3$	.24	.16	.13			.32	.39		.56	.45		
N-Org.												
PO_4-Tot.	5.3	5.4	.83	2.51		12.1	12.1		8.1	5.4		
-Sol.	.27	.19	.18	.05		.48	.28		.3	.14		
Solids-Diss.	190	240	275			224	207		240	222		
-Susp.	29960	12780	49225			27726	13063		3536	1968		
-Tot.	30150	13020	48500			49950	13270		3776	2190		
- Vol. T.	470	260	155			857	185		476	264		
Cl.												
SiO_2												
EH (MV)	360*	360*	365*	250*		310*	300*		450*	455*		
EH(mv)												
Fe	6.7	.27	.08	311								

Table I (cont'd)

ROCHESTER PROGRAM OFFICE
Great Sodus Bay Dredging Study
Chemical Data

Post Dredging Information - 1967

Date	10/17	10/17										
Sta., No.	166	166										
Depth (m)	Mud	H_2O										
Parameters, °C												
pH		7.7										
Spec. Cond.		340										
alkalinity		490										
turbidity												
DO		10.8										
BOD												
COD		6.0										
N-Tot. Kje.												
$N-NO_3$		.33										
N-Org.												
PO_4-Tot.												
-Sol.												
Solids-Diss.		190										
-Susp.		10										
-Tot.		200										
- Vol. T.		76										
Cl.												
SiO_2												
Ca												
Eh(mv)												
Fe												

* -- These values taken in labs.
IN - Inlet to Hoppers
OF - Overflow from Hoppers
CW - Composit water
C-M - Composit of mud

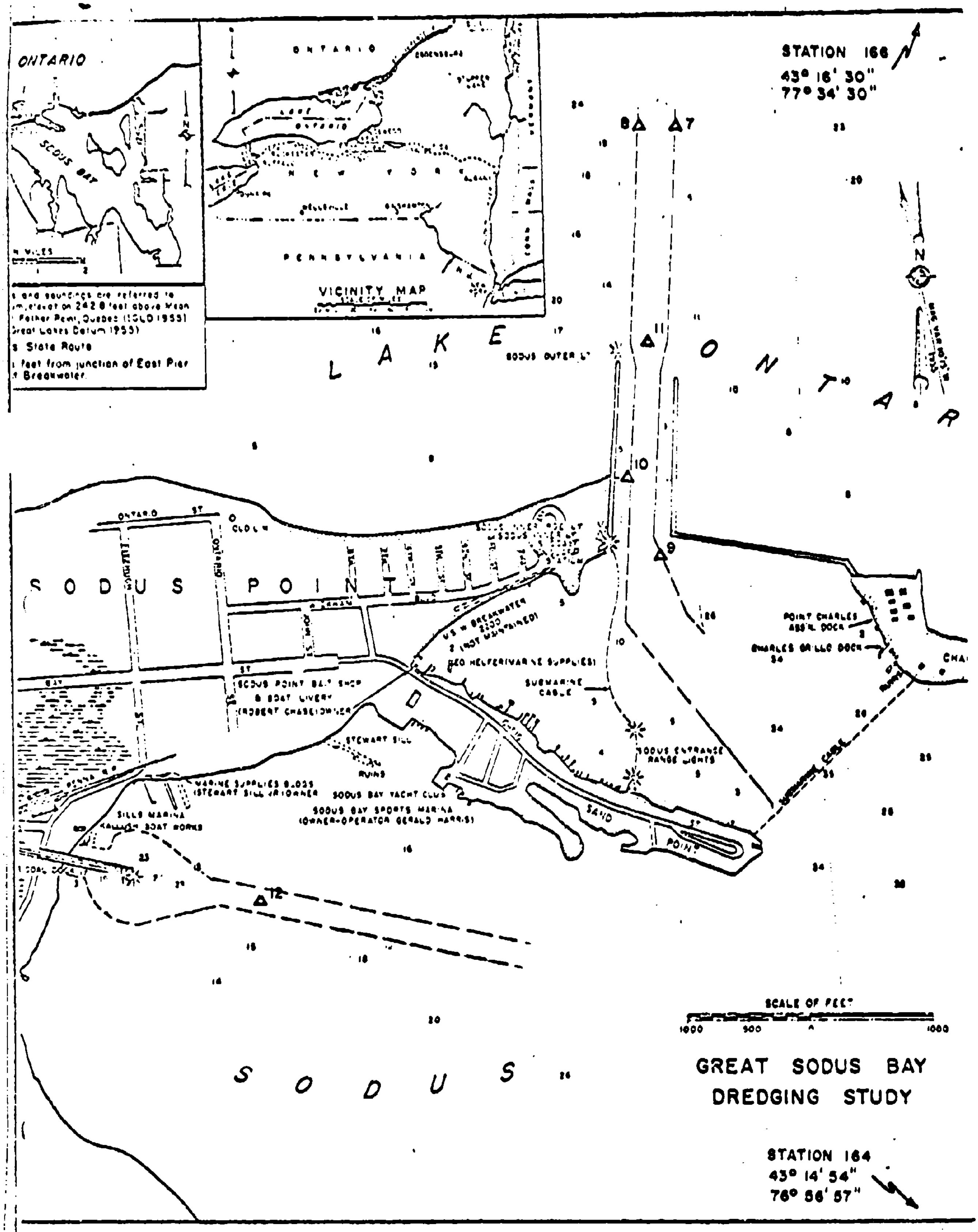
The number of Tubificidae found are indicative of a transitional condition,however, the presence of the clean water organisms (scuds) indicates the bottom is in fair condition and not grossly polluted. Such common organisms as *Ankistrodesmus*, *Pediastrum*, *Scenedesmus*, *Sphaerocystis*, and *Coelosphaerium*, were found in small numbers in the overlying waters thus indicating normal conditions for this time of the year.

TABLE 2

GREAT SODUS BAY DREDGING PROGRAM
SAMPLING STATION DESCRIPTIONS*

Station	Description
7	East side of approach channel 100' inside black can bouy #1, Sodus Bay
8	West side of approach channel 100' inside red can bouy #2, Sodus Bay
9	50 feet NNW of black can bouy #5, Sodus Bay approach channel
10	Mid-point of westside approach channel to Sodus Bay
11	Middle of channel 50 feet north of a line between bouys #3 and #4 at Sodus Bay entrance
12	Midway between bouys #3 and #4 on approach channel to coal dock
164	In center of Great Sodus Bay midway between Nicholas Point and the southern most point of Eagles Island (43° 14' 54" - 76° 56' 57")
166	Corp of Engineers Spoil Area in Lake Ontario (43° 16' 30" - 77° 34' 30")

* See Figure 12



STATION 166
43° 16' 30"
77° 34' 30"
ONTARIO
SODUS BAY
VICINITY MAP
ONTARIO
NEW YORK
PENNSYLVANIA
LAKE ONTARIO
SODUS OUTER LT
SODUS POINT
ONTARIO ST
SODUS POINT BAIT SHOP & BOAT LIVERY
STEWART SILL
RUINS
SODUS BAY YACHT CLUB
SODUS BAY SPORTS MARINA
SILLS MARINA
SUBMARINE CABLE
SODUS ENTRANCE RANGE LIGHTS
SAND POINT
POINT CHARLES
s State Route
SCALE OF FEET
1000 500 0 1000
SODUS
GREAT SODUS BAY
DREDGING STUDY
STATION 164
43° 14' 54"
76° 56' 57"

FIGURE 12

APPENDIX A 2

PILOT STUDY

Summer 1968

GREAT SODUS BAY

DISPOSAL OF DREDGINGS

U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Great Lakes Region
Rochester Program Office
Rochester, N. Y.

Correction made 9/16/68 - LRM LRM
Updated 12/10/68 - LRM LRM

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U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Great Lakes Region
Rochester Program Office
Rochester, N. Y.

GREAT SODUS BAY DREDGING STUDY

Summer 1968

Introduction

The following information pertains to pre during and post dredge samples collected by FWPCA and Corps of Engineers' personnel. Figure 1 shows the location of the stations sampled and Table VII describes each station.

The FWPCA water samples were collected from a small boat using PVC samplers and a Ponar or Petersen dredge for the muds. Both surface and bottom waters were sampled. The Lyman samples were taken during dredging near Station 10 from the inlet to and the overflow from the ships holding tanks. FWPCA personnel at the same time were sampling up and down stream of the dredge.

Predredge samples were collected (See Figure 1) on 6-28-68 at Stations 166, 11, 10, 12 and 164. The "during dredge" samples were taken on 7-11-68 from Stations 9, 10 and 166. The post dredge samples were taken on 8-1-68 at Stations 166, 8, 10, 12, and 164. A second set of post-dredge samples have also been collected (on 8-15-68) but the data, except for biology, is not yet available for this report.

All dredged material collected in the channel area was disposed of at a designated spoil area in Lake Ontario, Station 166.

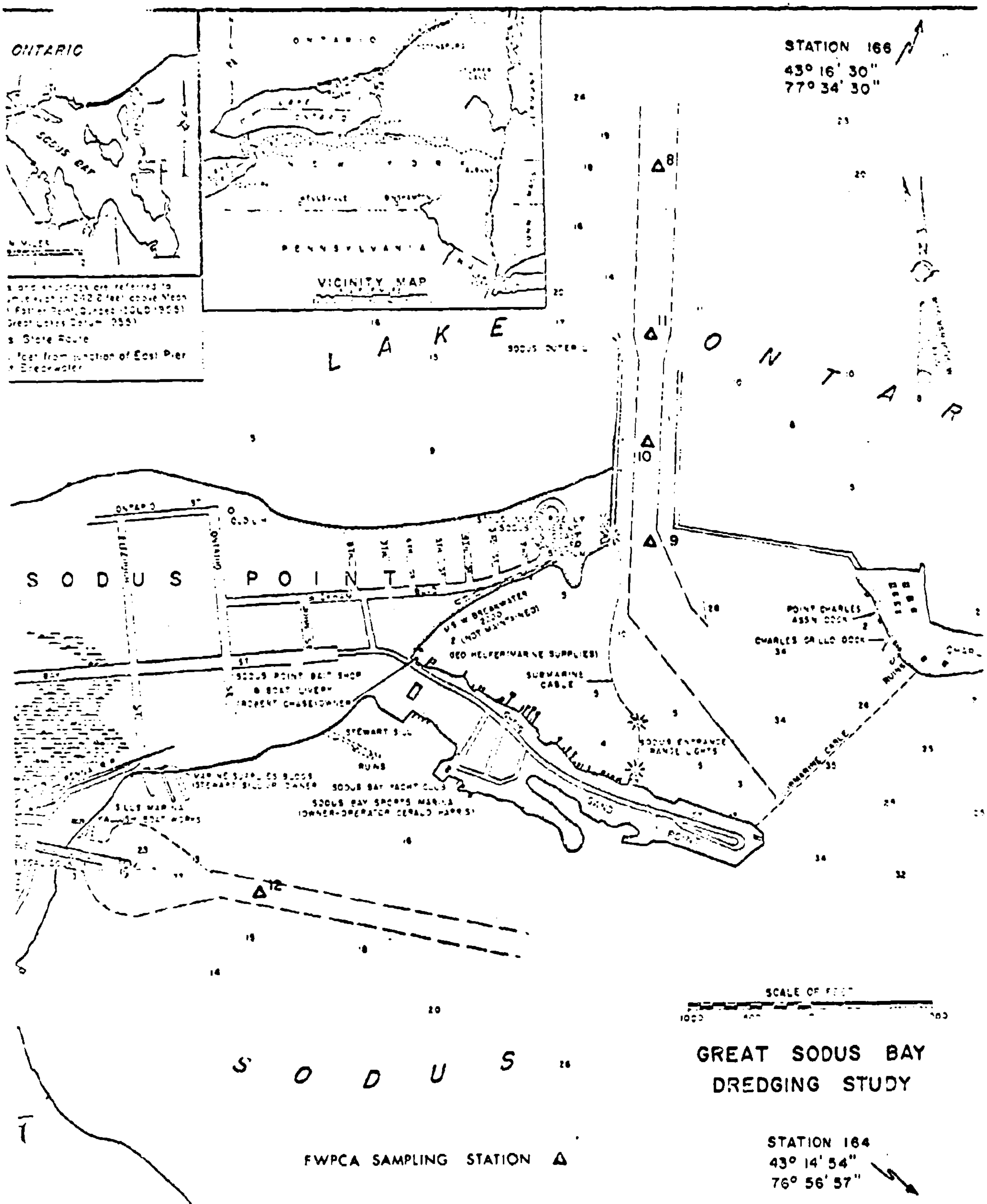

ONTARIO
SODUS BAY
VICINITY MAP
PENNSYLVANIA
STATION 166
43° 16' 30"
77° 34' 30"
LAKE ONTARIO
SODUS POINT
SODUS
GREAT SODUS BAY
DREDGING STUDY
FWPCA SAMPLING STATION Δ
STATION 164
43° 14' 54"
76° 56' 57"
SCALE OF FEET
POINT CHARLES ASSN DOCK
SUBMARINE CABLE
SODUS ENTRANCE RANGE LIGHTS
STEWART SILL
RUINS
SODUS BAY YACHT CLUB
SODUS BAY SPORTS MARINA
SODUS POINT BAIT SHOP
& BOAT LIVERY
8
9
10
11
12

FIGURE 1

Data

The data collected pertains to those parameters asked for by the consultants. In the case of Great Sodus Bay such information as coliform and streptococci counts, oil, grease and "tracer" determinations and physical descriptions of the sediments are not furnished because of time and/or lack of personnel.

Chemistry

Pre and Post Dredge Data - Tables II, IV and V give information on water and mud samples. Figures 2 through 16 A are graphical illustrations of the parameters examined. The data as presented under this heading indicates changes resulting from the dredging activities. The loadings to the lake at the spoil areas, however, cannot be based on the material removed from the harbor area. The loadings are determined from the dredged material in the Lyman hoppers. Much of the suspended, dissolved and volatile material in the bottom muds is transferred via the dredging operation through the overflow to the surface waters and is carried out to the lake or redeposited some place along the channel and, therefore, cannot be considered as being deposited in the spoil area. From the chemical and biological standpoint little or no change has taken place at the spoil area between pre and post dredge sampling (post dredge mud samples could not be found in the rocky bottom of the spoil area). The dredging of the approach channel also did not materially change the characteristics of the water or bottom sediments. (Stations 8 - 11).

At the mid-pier station 10, very little change occurred in the overlying water, however, considerable change can be noted in the reduction of BOD and COD in the post dredged mud samples. This is also reflected in the low silica content of the pre-dredge sediments and the reduced chlorine demand of the post dredge samples. This would indicate a substantial amount of organic or volatile material being removed.

Station 164 in Sodus Bay, not affected by dredging, was used as a base to determine changes in the source of the sediment and organic loadings to the channel. The pre and post dredge samples showed some variation in the over-lying water, but of such a nature the changes did not materially affect conditions at the dredging site. One exception might be phosphates. Phosphates were high in the muds prior to dredging. The low phosphates in the post dredge muds may have been caused by the leaching out of the chemical or the erosion of organic matter during the spring runoff.

Lyman Water Samples - Table III gives information on water and mud samples. Figures 17 through 23 are graphical illustrations of the parameters examined. It is pointed out that the Corps of Engineers dispose of about 30,000 cubic yards or about 6 million gallons of sediment each year in a designated spoil area.

The table and graph shows the realtive conditions of the water surrounding the dredge and the water - sediment mixture in the hoppers. By use of inlet and outlet samples alone a true value of the hopper contents cannot be determined. However on the basis of chemical determinations and the quantity of materials, the chemical and organic load imposed on the disposal area can be approximated. Assuming an average current speed of 0.3 ft/sec. moving through a cross section of the spoil area and assuming the disposal of dredged material is uniformly distributed across the spoil area it is estimated that 30 million gallons of water pass through the spoil area during each dumping cycle. It is not known how many dumps are made per day, but if it is assumed a minimum of ten dumps per day for six days take place, then some 1.8 billion gallons of water would be available to dilute the 30,000 cubic yards (6 million gallons) of dredged material. How well the material is mixed will depend on the physical makeup of the sediments, initial discharge dilutions, diffusion and turbulence.

It can be seen from the table and the graphs that the dredge does cause a distinct change in characteristics of the channel water as the water and sediments are pumped into the dredge. Some of the parameters show a change, the BOD increased but is quite insignificant in view of the quantity of dissolved oxygen contained in the waters at the dumping ground. The nutrient (phosphate) content of the dredged water increases markedly over lake water nutrient content, however since the 30,000 cubic yards represent about 1500 pounds of displaced phosphates over a weeks time in moving water, then there is little likelihood of meaningful (time wise) enrichment to the spoil area water. Analysis for silica was not made on the Lyman samples, but the bottom material in the dredge area (Station 10) showed about 70% silica and 20% water, suggesting that the suspended material represented less than 10% of the dredged material. Visually the laboratory samples of the intake material appeared to be fine sand. On this basis the volatile material is well below 1% of the material placed over the spoil area. Less than 500,000 pounds of volatile matter was placed over the dredged area in the week of dredging.

Biology

Sediment samples for bottom fauna analysis were collected along with the chemical samples prior to, and after the dredging operations in an attempt to assess the biological condition of the sediments and to determine if the dredging operations significantly altered the compositional structure of the benthic macroinvertebrate communities. Since chemical and biological samples were both taken from the same sediment grab, the biological data are necessarily only meaningful qualitatively.

Two faunal groups, the Chronomidae (midges) and Oligochaeta (worms) dominated the bottom fauna at each of the stations sampled, with scuds, caddisflies, fingernail clams and snails appearing occasionally in the samples. The oligochaetes were not separated into taxonomic groups, but the midges were identified to genus when possible.

A total of seven midge genera were found in the samples, with a maximum of five genera occurring at three stations. The most common midges collected, Chironomus spp., forms often associated with organically enriched sediments, were taken at all stations except at the spoil area in the open lake; here the intolerant forms Procladius spp., Tanytarus spp. and two unidentified forms were collected. Although the presence of Chironomus spp., in association with moderate oligochaete densities is suggestive of eutrophic conditions, the fairly diverse assemblage of animals including the intolerant midges Tanytarsus spp., Procladius spp., Polypedilum spp. and Cryptochironomus spp., along with clean water scuds is evidence that the sediments are not excessively enriched.

The dredging operation had no measurable effects upon the benthos, discernible within the limits of sampling reliability. Because quantitative benthic samples were not taken from all stations before and after dredging, it is impossible to compare the existing data in meaningful manner. However, the generic composition of the benthic fauna remained essentially unchanged at all stations after dredging.

Conclusion

From the data presented it is evident that prior to dredging the channel sediments at Station 10 could be considered to be polluted or a pollutant. However, upon dredging the muds are so diluted that their strength is markedly reduced when pumped aboard the dredge. Upon being dumped, the strength of the residue is further reduced by the massive movement of Lake Ontario water across the spoil area. The pre and post dredging sampling at the spoil area and Station 11 indicate little chemical and biological changes take place to the detriment of the lake. Unless the volume and strength of the dredged material continues to increase it is concluded that the dredgings from the Great Sodus Bay channel do not constitute a major pollution hazard to Lake Ontario.

Recommendation

That the dredged material from the Great Sodus Bay channel between Stations 8 and 9 be allowed to be dumped at the Sodus spoil area in Lake Ontario.

Table I

ROCHESTER PROGRAM OFFICE
Great Sodus Bay Dredging Study
Chemical Data

Predredge (Water) mg/l

June 1968

Date	6-28	6-28	6-28	6-28	6-28	6-28	6-28	6-28	6-28	6-28
Sta. No.	166	166	11	11	10	10	12	12	164	164
Depth (m)	Top	Bott	Top	Bott	Top	Bott	Top	Bott	Top	Bott
Parameters										
pH	8.2	8.0	8.1	8.0	7.95	8.20	8.0	7.95	8.0	7.9
Spec. Cond. *	340	344	390	310	252	256	308	290	344	344
turbidity	0.80	.90	1.40	1.10	1.6	1.4	1.10	1.40	1.10	2.6
DO	11.5	12.3	11.0	13.3	9.3	9.1	9.3	12.85	8.9	9.1
BOD	1.0	1.2	2.4	1.4	—	—	1.7	—	1.8	1.1
N-Tot. Kje.	.244	.764	.432	.328	.588	.336	.396	.396	.504	.492
$N-NO_3$	.090	.280	.150	.220	.09	.26	.140	0.10	.080	.170
$N-NH_3$	.100	.560	.108	.100	.132	.08	.048	.060	.096	.132
PO_4-Tot.	.09	.09	.13	.10	.17	.12	.16	.16	.16	.20
-Sol.	.05	.07	.02	.06	.12	.08	.11	.10	.12	.13
Solids Susp	4	15	2	5	18	11	3	17	8	8
Vol. -Susp.	3	7	1	5	3	3	3	4	8	6
Alkalinity	98	102	94.0	104	100	100	96	102	97	100
Chloride	26.5	26.5	26.9	26.3	27.0	29.2	25.3	28.1	25.8	24.8
Lab #	52-D	53-D	49-D	50-D	57-D	58-D	51-D	56-D	54-D	55-D

* Micromhos/cm

Table II

ROCHESTER PROGRAM OFFICE
Great Sodus Bay Dredging Study
Chemical, Data *

Predredge (Mud)
mg/Kg

Date	6/28 1968	6/28	6/28	6/28	6/28
Sta. No.	166	11	10	12	164
Depth (m)					
Parameters					
pH					
BOD	327	327	7.650	2,350	2,892
COD	1,259	2,000	32,255	8,724	10,885
N-Tot. Kje.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
$N-NO_3$	71	[illegible]	[illegible]	[illegible]	[illegible]
$N-NH_3$					
PO_4-Tot.	1,621	1,973	33,238	3,764	4,224
-Sol.	5.2	1.98	107.0	13.0	25.0
Solids Total%	76.2	77.1	30.6	39.2	38.4
~~XXX~~%. Vol. Total %	1.11	0.47	26.97	7.56	9.55
Oil-Grease	218	1,116	8,222	1,300	1,890
Chlorine Demand	0	0	11,535	9,515	10,989
% S_1O_2	69.4	72.4	16.3	31.0	28.5
% H_2O	23.76	22.1	69.36	60.85	61.51

Results given in mg/k_g on Dry basis unless specified otherwise.

Table III

ROCHESTER PROGRAM OFFICE
Great Sodus Bay Dredging Study
Chemical Data

Lyman Samples
mg/l

July 1968

Date	7-11	7-11	7-11	7-11	7-11	7-11	7-11	7-11	7-11	7-11
Sta. No.	166	166	10	10	9	9	Samples from Dredge			
Depth (m)	Top	Bott	Top	Bott	Top	Bott	In	Out	In	Out
Parameters							8	A.M.	12	Noon
pH	8.7	8.5	8.4	8.5	8.4	8.1	7.7	7.6	7.6	7.8
Spec. Cond.*	360	358	350	340	340	350	314	330	358	350
turbidity	2.0	1.1	2.8	3.8	1.1	0.9	420	100	550	350
DO	11.8	10.4	--	10.0	9.8	8.3	—	—	—	—
BOD	3.5	1.9	4.5	7.0	2.4	4.0	51	17	51.0	22.0
N-Tot.Kjs.	.380	.372	.504	.468	.240	.317	67.7	29.6	11.0	18.5
$N-NO_3$	.03	.06	.04	.04	.04	.05	2.75	6.90	1.90	3.15
$N-NH_3$	.024	.048	.084	.048	.024	<.005	8.7	2.1	2.7	3.7
PO_4-Tot.	.22	.10	.26	.25	.15	.16	27.94	33.00	24.00	6.53
-Sol.	.17	.07	.12	.14	.09	.09	.50	.48	.54	.43
Solids										
-Susp.	6	3	5	8	4	10	5650	3203	6892	2705
-Susp.Vol.	5	0	5	5	2	8	360	168	418	113
Chlorides	24.9	25.6	26.7	25.4	25.1	26.2	25.6	25.0	26.2	27.7
Alkalinity	108	100	98	100	96	98	104	110	124	100
Lab #	69-D	71-D	72-D	73-D	70-D	74-D	77-D	78-D	76-D	75-D
Chlorine Demand	—	—	—	—	—	—	40	16	137	33

* Micromhos/cm

Table III A

ROCHESTER PROGRAM OFFICE
Great Sodus Bay Dredging Study
Chemical, Data

Lyman Samples (Mud)
mg/kg

Date	7/11/68	7/11/68	7/11/68									
Sta. No.	166	10	9									
Depth (m)												
Parameters												
pH												
Spec. Cond.												
turbidity												
BOD	392	542	1,860									
COD	2,090	750	2,272									
N-Tot.Kje.	141	197	161									
$N-NO_3$	32	74	110									
$N-NH_3$												
PO_4-Tot.	727	944	453									
-Sol.	0.50	1.26	6.05									
Solids												
-Susp.												
-Susp.Vol.												
Total Solids %	76.5	79.2	66.1									
Total Vol. %	0.74	0.89	2.85									
% SiO_2	70.5	72.3	56.5									
% Water	23.54	20.83	33.89									
Chlorine Demand	0	0	2,299									
Oil & Grease	397	992	1,238									

Table IV

ROCHESTER PROGRAM OFFICE
Great Sodus Bay Dredging Study
Chemical Data

Post Dredge (Water) August 1968
mg/l

Date	8-1	8-1	8-1	8-1	8-1	8-1	8-1	8-1	8-1	8-1
Sta. No.	166	166	8	8	10	10	12	12	164	164
Depth (m)	0	26	0	8	0	8	0	10	0	10
Parameters										
pH	8.35	8.30	8.20	8.10	8.30	8.40	8.40	8.45	8.40	8.20
Spec. Cond.*	300	304	310	314	318	322	328	330	330	330
turbidity	1.70	0.80	0.80	0.80	0.7	1.3	0.8	0.7	0.6	0.6
DO	9.7	--	--	8.4	--	8.5	8.7	7.8	7.8	8.8
Bod	1.6	1.3	1.4	1.7	2.5	2.3	3.0	2.0	1.8	2.0
N-Tot.Kje.	.54	.54	.65	.65	.90	.91	.77	.79	.74	.72
$N-NO_3$	.04	.05	.04	.34	.04	.05	.05	.02	.08	.10
$N-NH_3$	.06	.06	.05	.08	.10	.15	.05	.09	.05	.05
PO_4-Totl.	.10	.10	.10	.12	.17	.18	.17	.15	.18	.17
-Sol.	.06	.06	.08	.06	.11	.11	.10	.11	.11	.10
Solids Susp.	3	3	5	3	35	2	5	8	3	2
Vol. Susp.	2	2	2	3	8	1	2	0	3	0
Chloride	27.1	26.7	26.7	26.7	26.0	26.0	25.5	26.0	26.0	27.1
Alkalinity	94	88	90	88	90	96	86	92	92	92
Lab. #	97-D	98-D	99-D	100-D	101-D	102-D	103-D	104-D	105-D	106-D
COD	8.1	9.0	11.1	43.0	15.9	23.4	36.3	--	--	--

* Micromhos/cm

Table II

ROCHESTER PROGRAM OFFICE
Great Sodus Bay Dredging Study
Chemical Data

Post Dredge (Mud)
mg/kg

Date	8-1-68	8-1-68	8-1	8-1-68	8-15	8-15	8-15	8-15
Sta. No.	8	10	12	164	11	10	9	164
Depth (m)								
Parameters								
pH								
BOD	4,150	687	2,758	3,764	776	571	950	5000
COD	3,452	2,407	8,681	11,196	1,851	1,845	1,581	11,174
N-Tot. Kje.	3,384	73	1,911	[illegible]	322	[illegible]	[illegible]	[illegible]
$N-NO_3$	471	34	[illegible]	391	144	37	129	1,034
$N-NH_3$								
PO_4-Totl.	2,547	2,009	5,545	4,395	1,081	1,281	2,000	2,285
-Sol.	33.9	4.27	5.72	32.0	1.30	1.06	4.20	7.50
Total Solids %	53.1	70.2	34.9	28.1	75.1	75.2	70.2	26.4
Total Vol	3.98	2.05	7.93	9.26	1.35	1.57	2.38	9.80
Oil & Grease	1,452		1,463	1,596	535	965	363	1,246
Chlorine Demand	10,735	569	10,401	10,320	570	664	1,139	13,750
SiO_2 %	31.5	62.5	27.3	21.6	68.6	—	63.2	15.8
% H_2O	46.91	29.81	65.08	71.13	24.91	24.76	29.77	73.6

GREAT SODUS BAY DREDGING STUDY – 1968

Table 6

Bottom Fauna Distribution

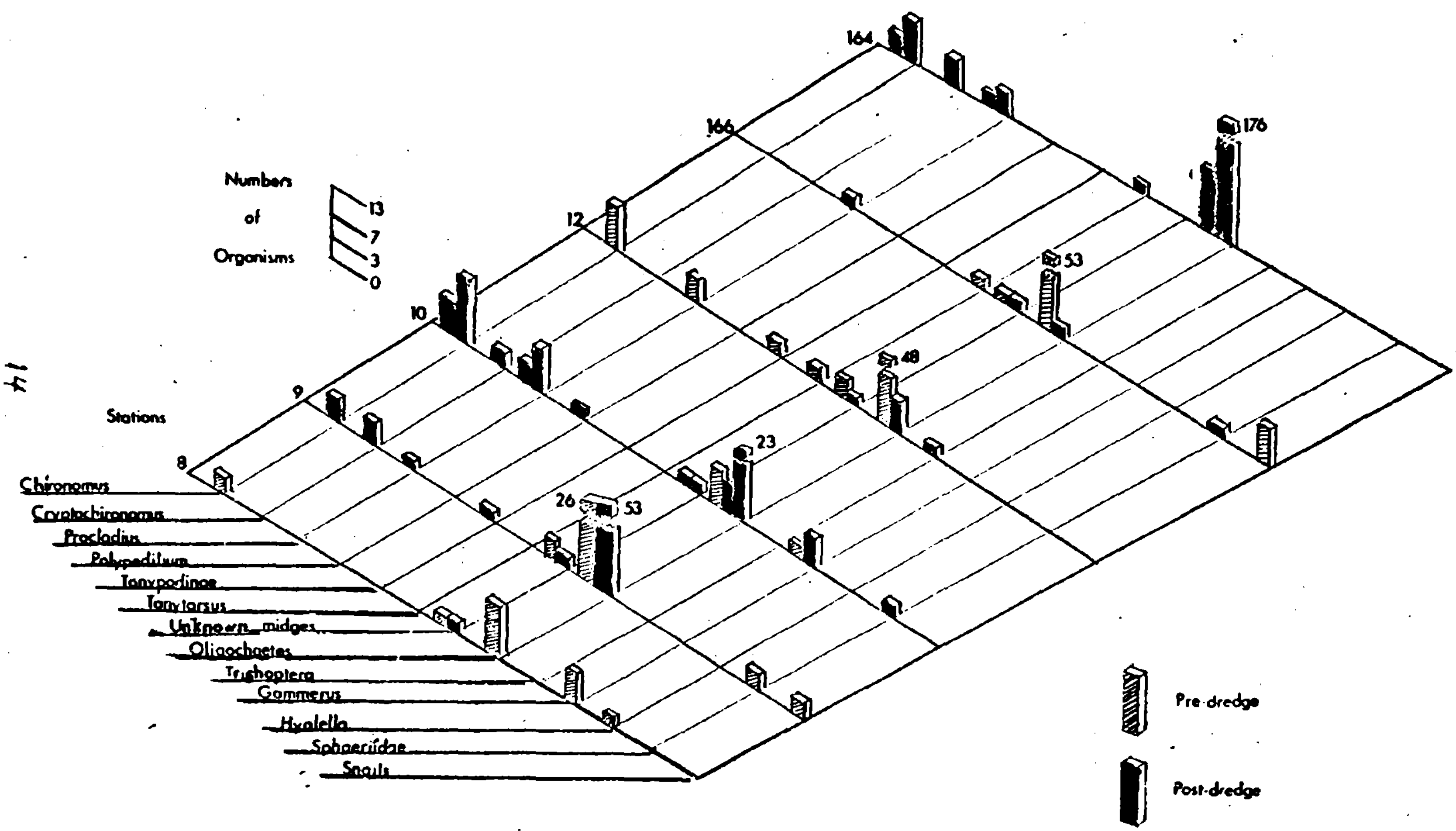


TABLE VII

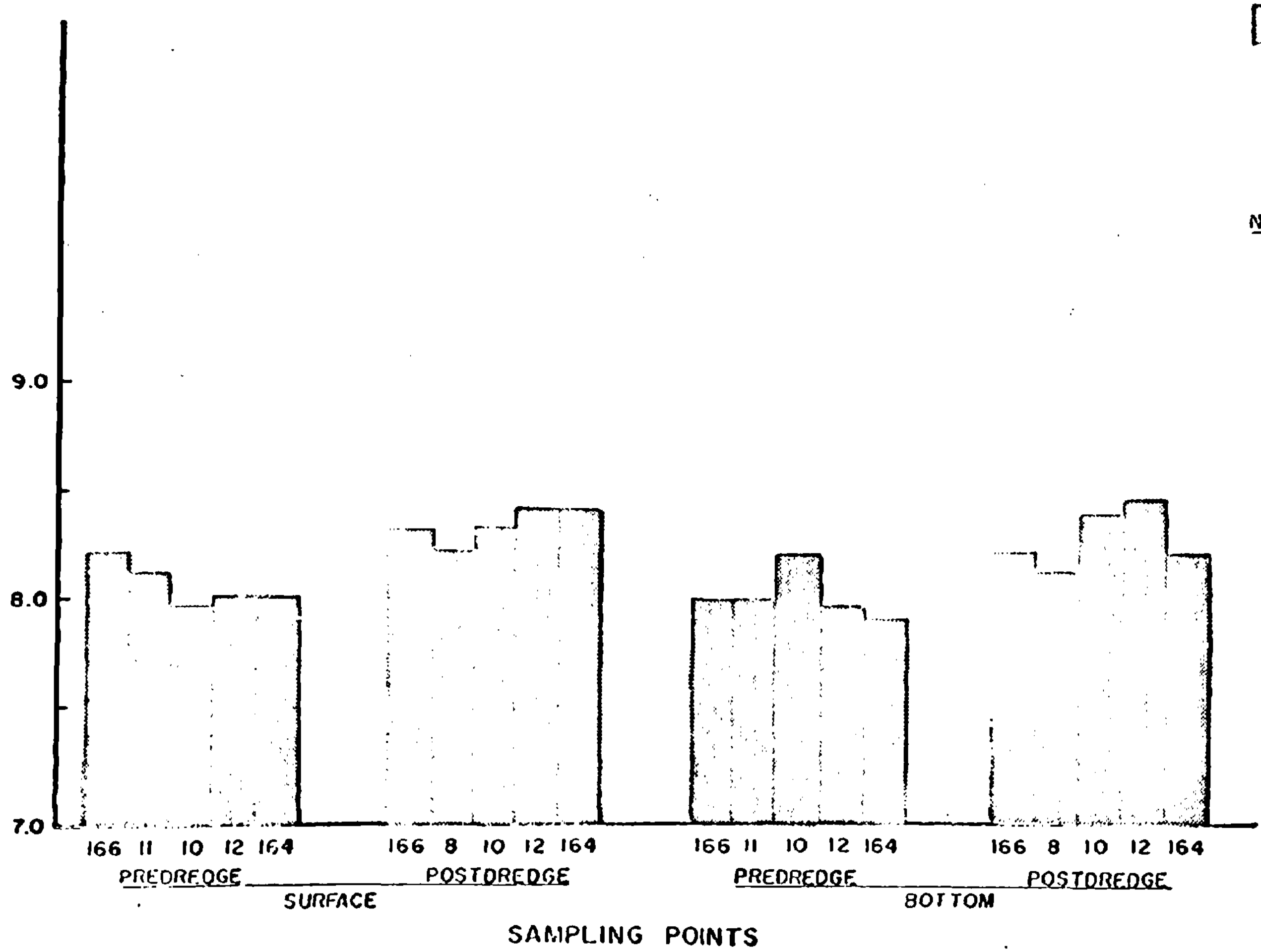
GREAT SODUS BAY DREDGING PROGRAM
STATION DESCRIPTIONS*

Station	Description
8	Midstream of approach channel 1,000 feet north of Sodus outer light
9	Fifty feet NNW of black can buoy #5, Sodus Bay approach channel.
10	Midstream of approach channel mid-way between the north and south ends of channel breakwaters.
11	Middle of channel 50 feet north of a line between buoys #3 and #4 at Sodus Bay entrance.
12	Mid-way between buoys #3 and #4 on approach channel to coal dock.
164	In center of Great Sodus Bay mid-way between Nicholas Point and the southern most point of Eagles Island. (43° 14' 54" - 76° 56' 57")
166	Corps of Engineers Spoil area in Lake Ontario (43° 16' 30" - 77° 34' 30")

* See Figure 1

GREAT SODUS BAY DREDGING STUDY - 1968

pH



LEGEND

Water sample

NOTE

Predredge samples taken 6/28/68.

Postdredge samples taken 8/1/68.

FIG. 2

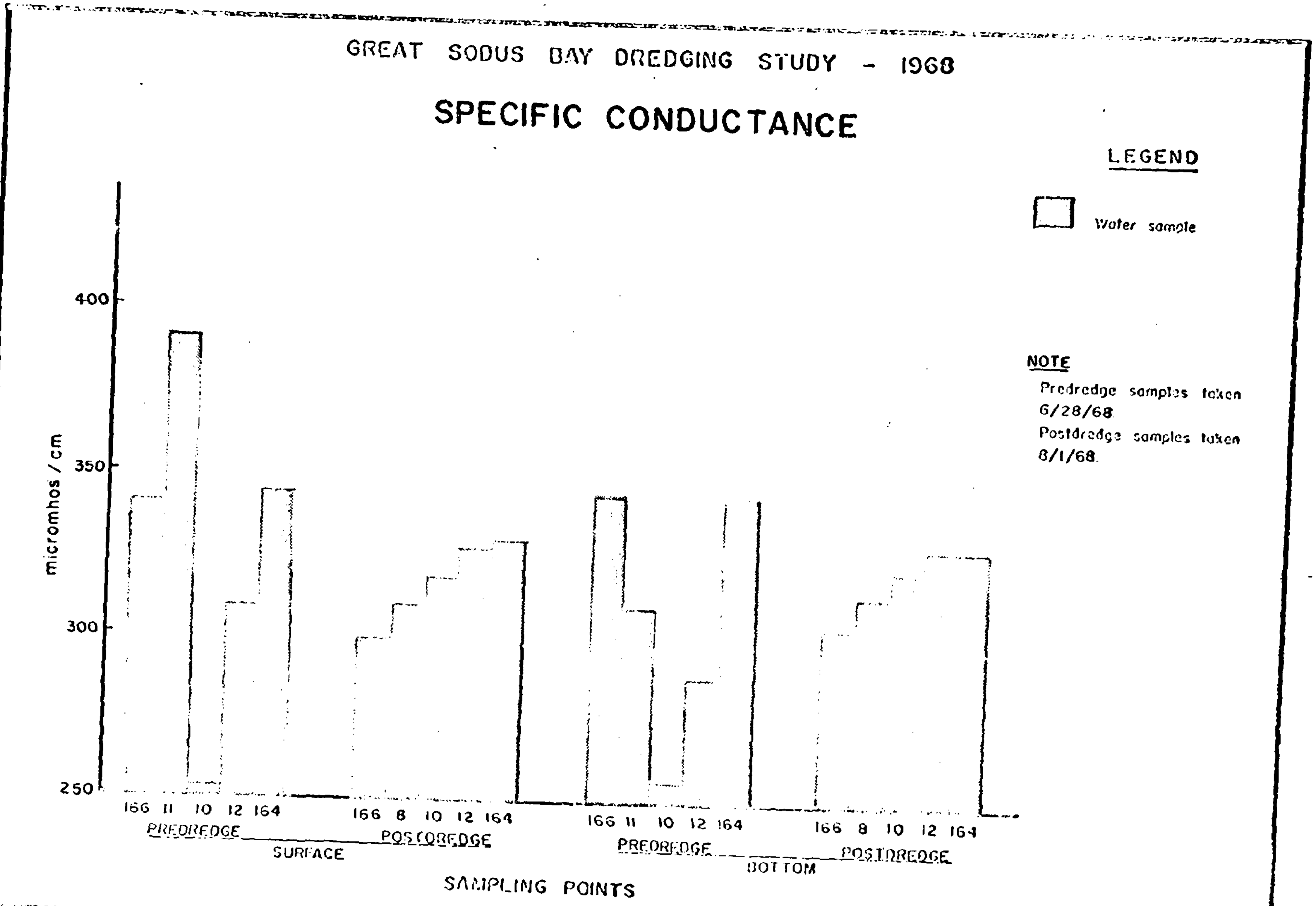

GREAT SODUS BAY DREDGING STUDY - 1968
SPECIFIC CONDUCTANCE
LEGEND
Water sample
NOTE
Predredge samples taken 6/28/68
Postdredge samples taken 8/1/68
micromhos / cm
400
350
300
250
166 11 10 12 164
PREDREDGE
166 8 10 12 164
POSTDREDGE
SURFACE
166 11 10 12 164
PREDREDGE
166 8 10 12 164
POSTDREDGE
BOTTOM
SAMPLING POINTS

FIG 3

GREAT SODUS BAY DREDGING STUDY - 1968

TURBIDITY

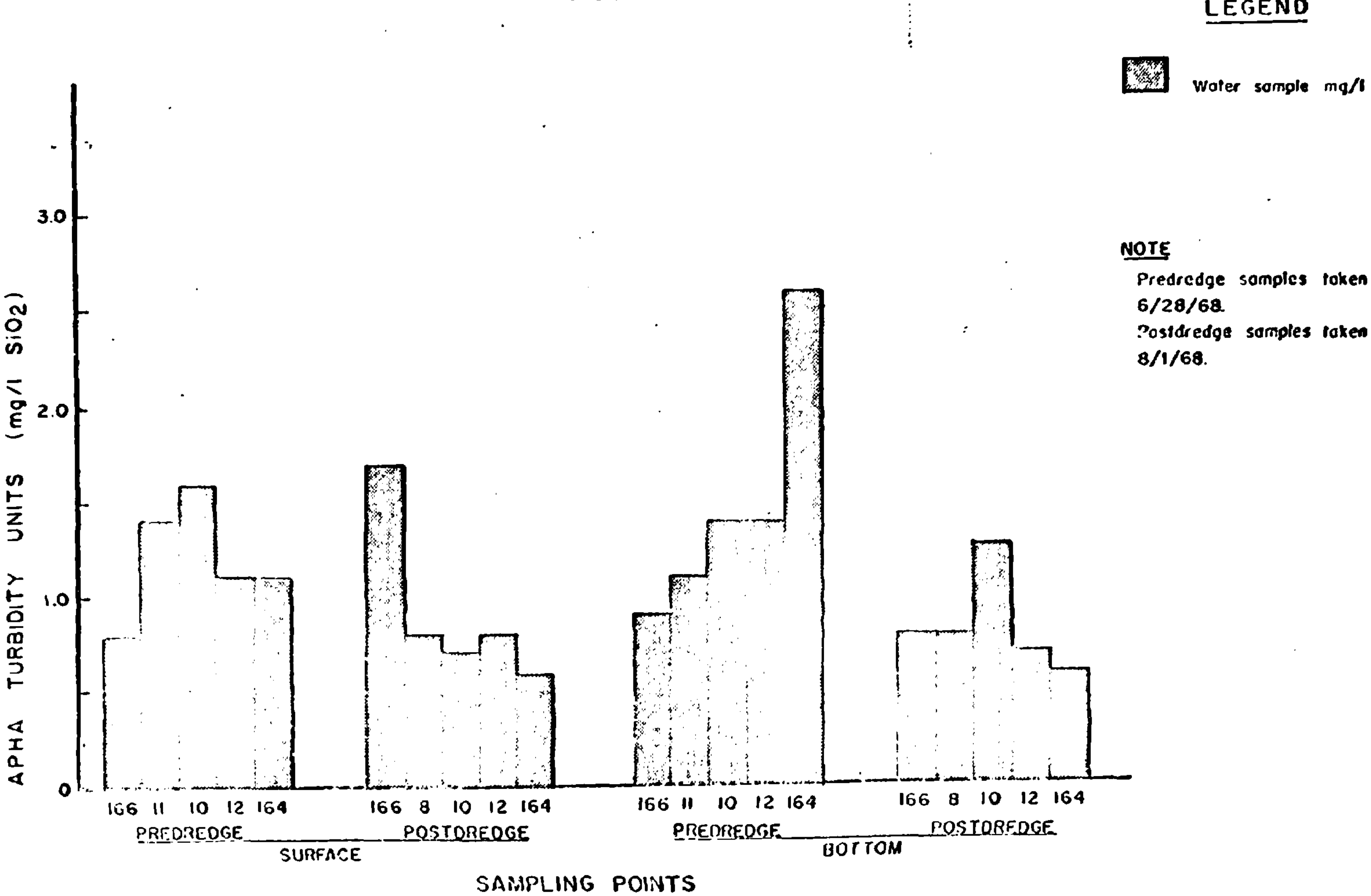


FIG 4

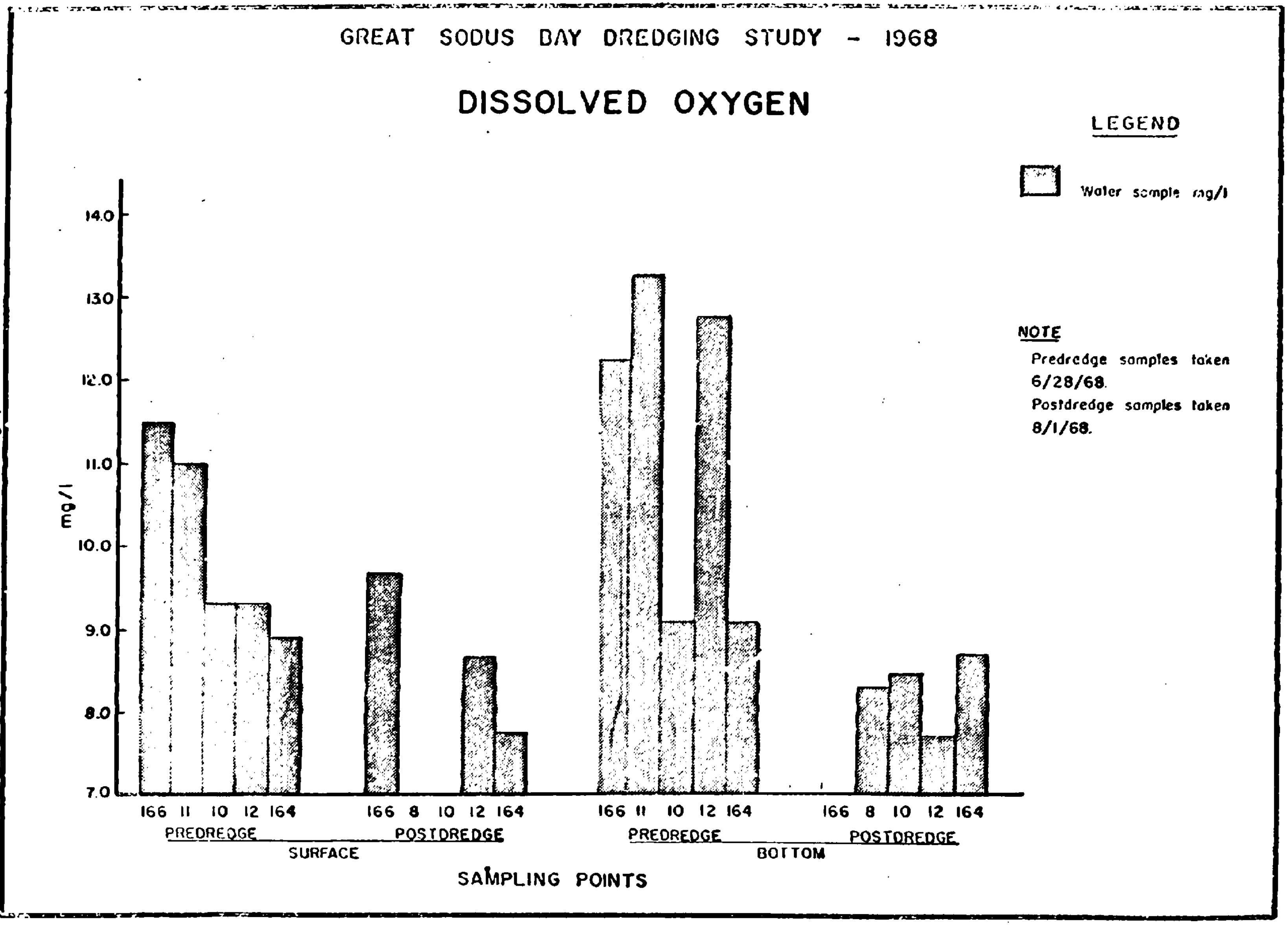
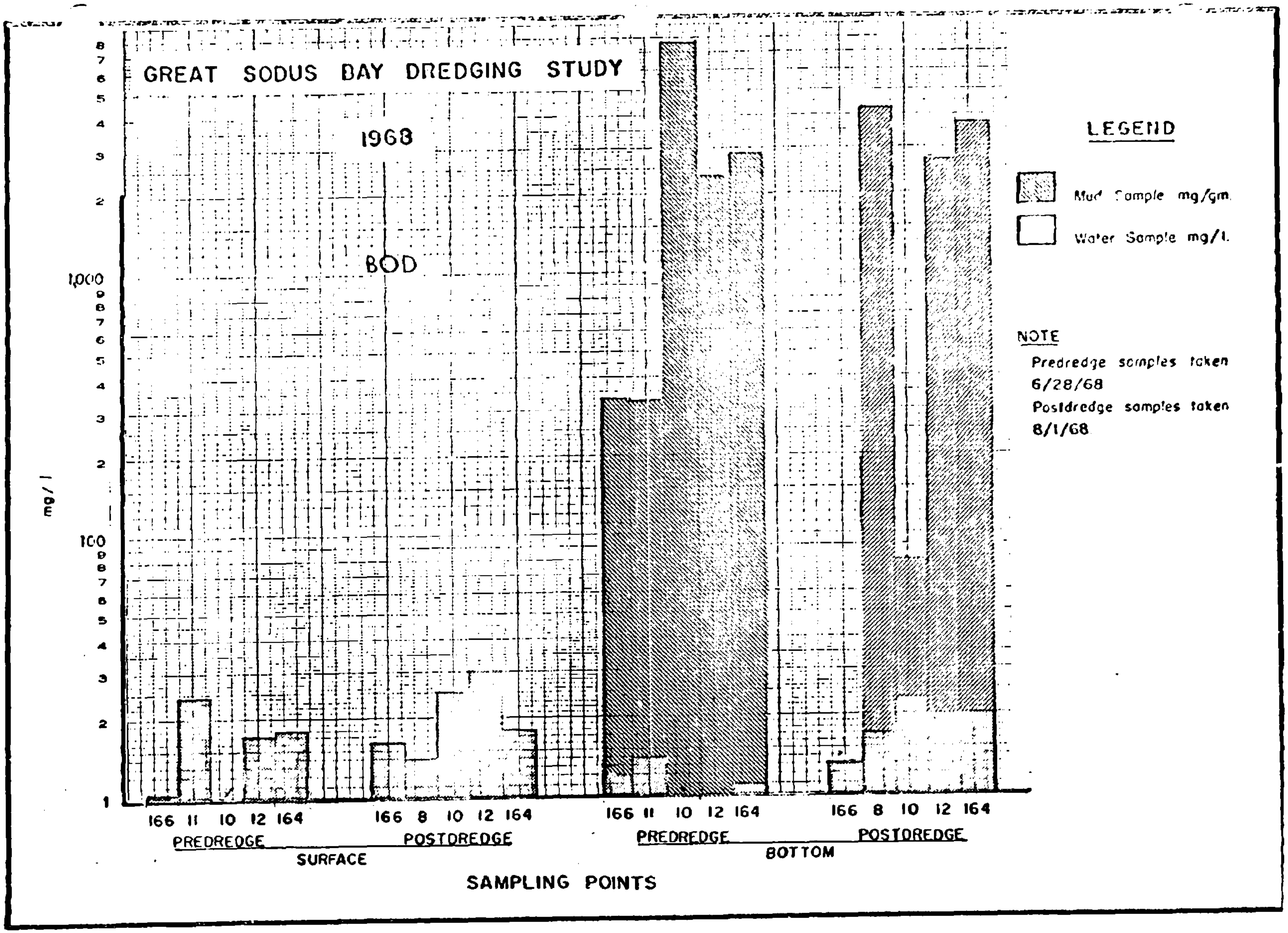

GREAT SODUS BAY DREDGING STUDY - 1968
DISSOLVED OXYGEN
LEGEND
Water sample mg/l
NOTE
Predredge samples taken 6/28/68.
Postdredge samples taken 8/1/68.
mg/l
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
166 11 10 12 164
PREDREDGE
166 8 10 12 164
POSTDREDGE
SURFACE
166 11 10 12 164
PREDREDGE
166 8 10 12 164
POSTDREDGE
BOTTOM
SAMPLING POINTS

FIG 5



GREAT SODUS BAY DREDGING STUDY
1968
BOD
LEGEND
Mud Sample mg/gm.
Water Sample mg/l.
NOTE
Predredge samples taken 6/28/68
Postdredge samples taken 8/1/68
mg/l
1,000
100
166 11 10 12 164
PREDREDGE
166 8 10 12 164
POSTDREDGE
SURFACE
BOTTOM
SAMPLING POINTS

FIGURE 6

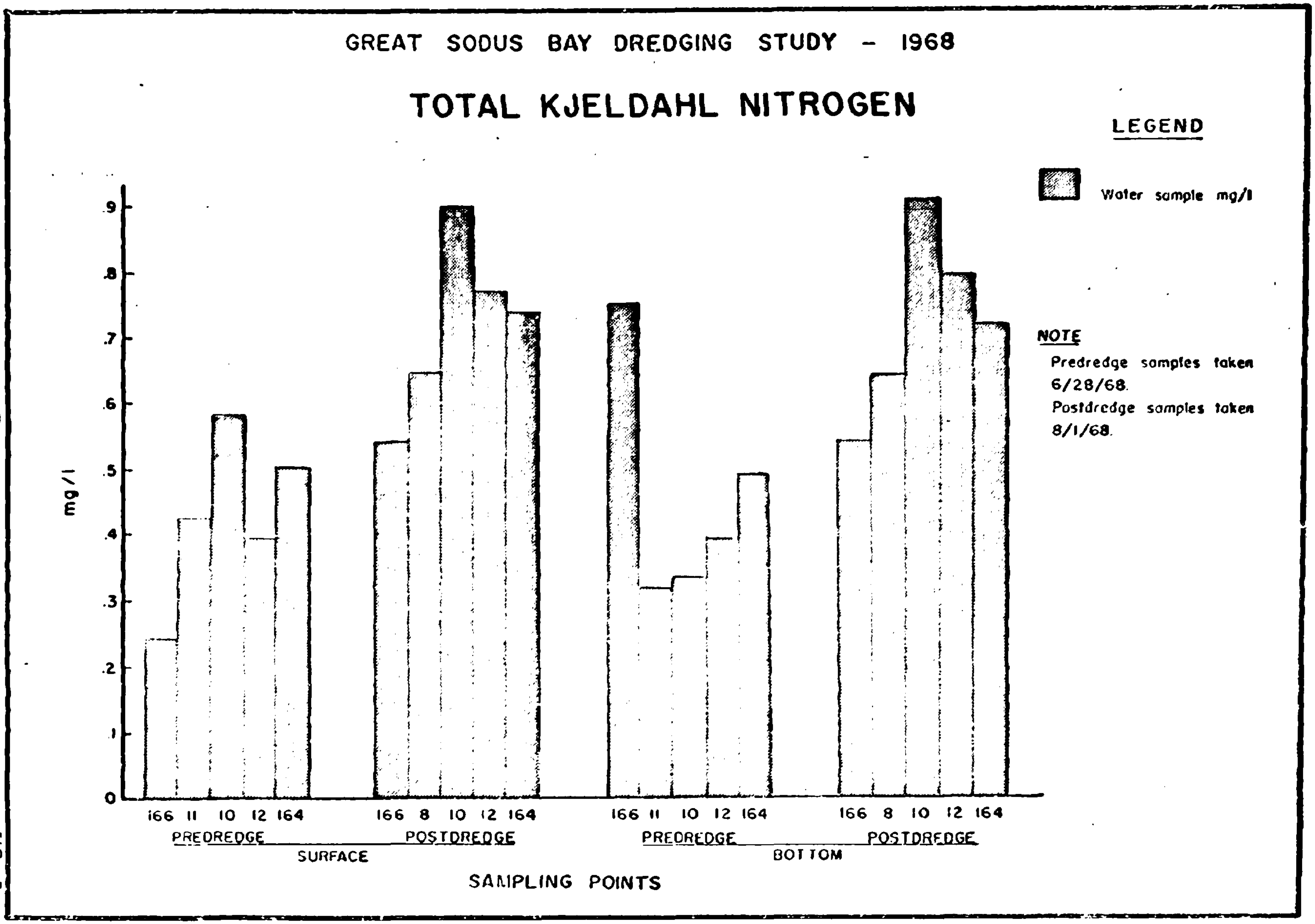

GREAT SODUS BAY DREDGING STUDY - 1968
TOTAL KJELDAHL NITROGEN
LEGEND
Water sample mg/l
NOTE
Predredge samples taken 6/28/68.
Postdredge samples taken 8/1/68.
mg/l
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
166 11 10 12 164
PREDREDGE
166 8 10 12 164
POSTDREDGE
SURFACE
166 11 10 12 164
PREDREDGE
166 8 10 12 164
POSTDREDGE
BOTTOM
SAMPLING POINTS

FIG 7

GREAT SODUS BAY DREDGING STUDY - 1968

NITRATES - N - NO_3

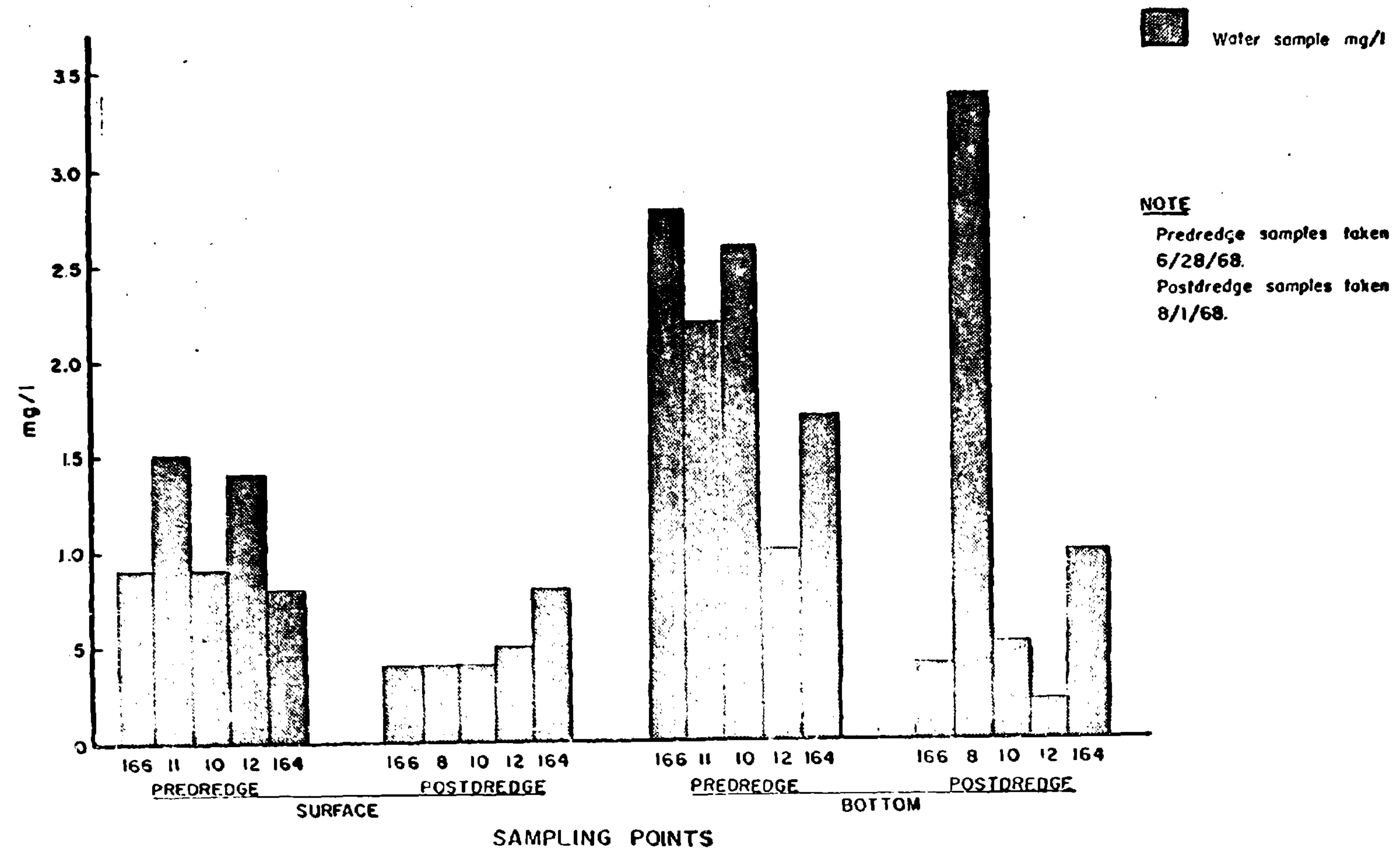
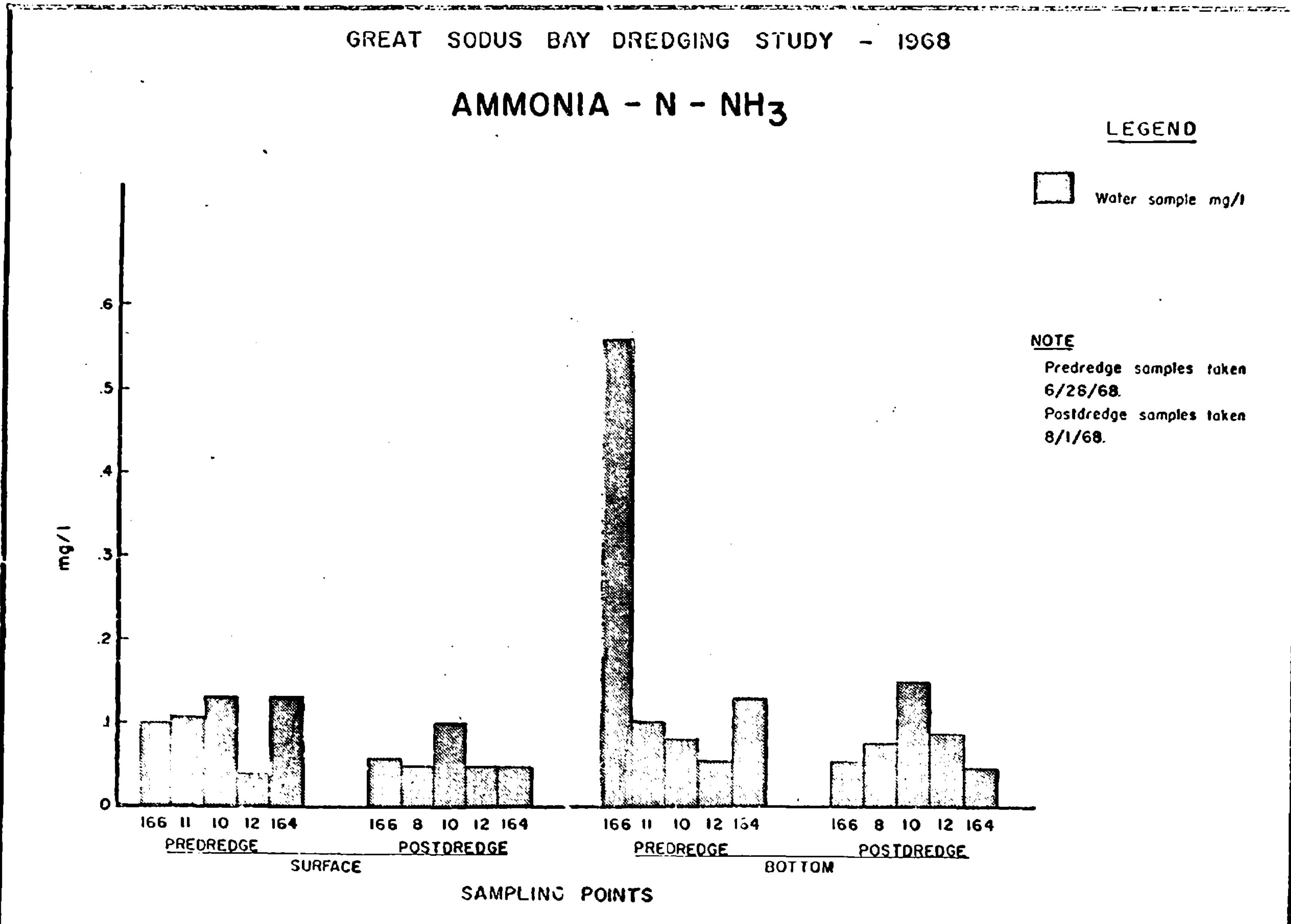


FIG 8



GREAT SODUS BAY DREDGING STUDY - 1968
AMMONIA - N - NH3
LEGEND
Water sample mg/l
NOTE
Predredge samples taken 6/26/68.
Postdredge samples taken 8/1/68.
mg/l
0
.1
.2
.3
.4
.5
.6
166 11 10 12 164
PREDREDGE
166 8 10 12 164
POSTDREDGE
SURFACE
166 11 10 12 164
PREDREDGE
166 8 10 12 164
POSTDREDGE
BOTTOM
SAMPLING POINTS

FIG 9

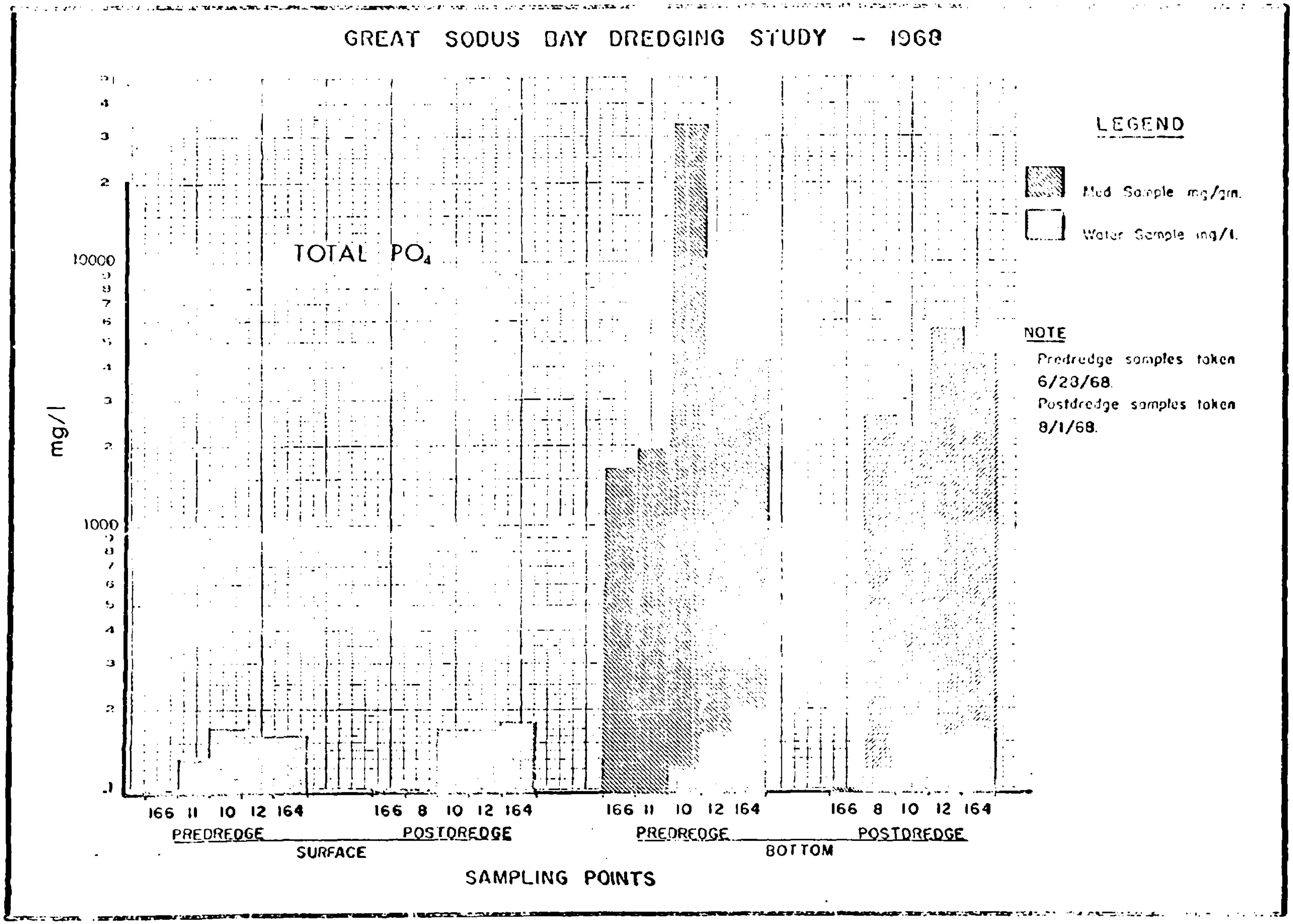

GREAT SODUS BAY DREDGING STUDY - 1968
TOTAL PO_4
mg/l
10000
1000
LEGEND
Mud Sample mg/gm.
Water Sample mg/l.
NOTE
Predredge samples taken 6/23/68.
Postdredge samples taken 8/1/68.
166 11 10 12 164
PREDREDGE
166 8 10 12 164
POSTDREDGE
SURFACE
166 11 10 12 164
PREDREDGE
BOTTOM
166 8 10 12 164
POSTDREDGE
SAMPLING POINTS

FIGURE 10

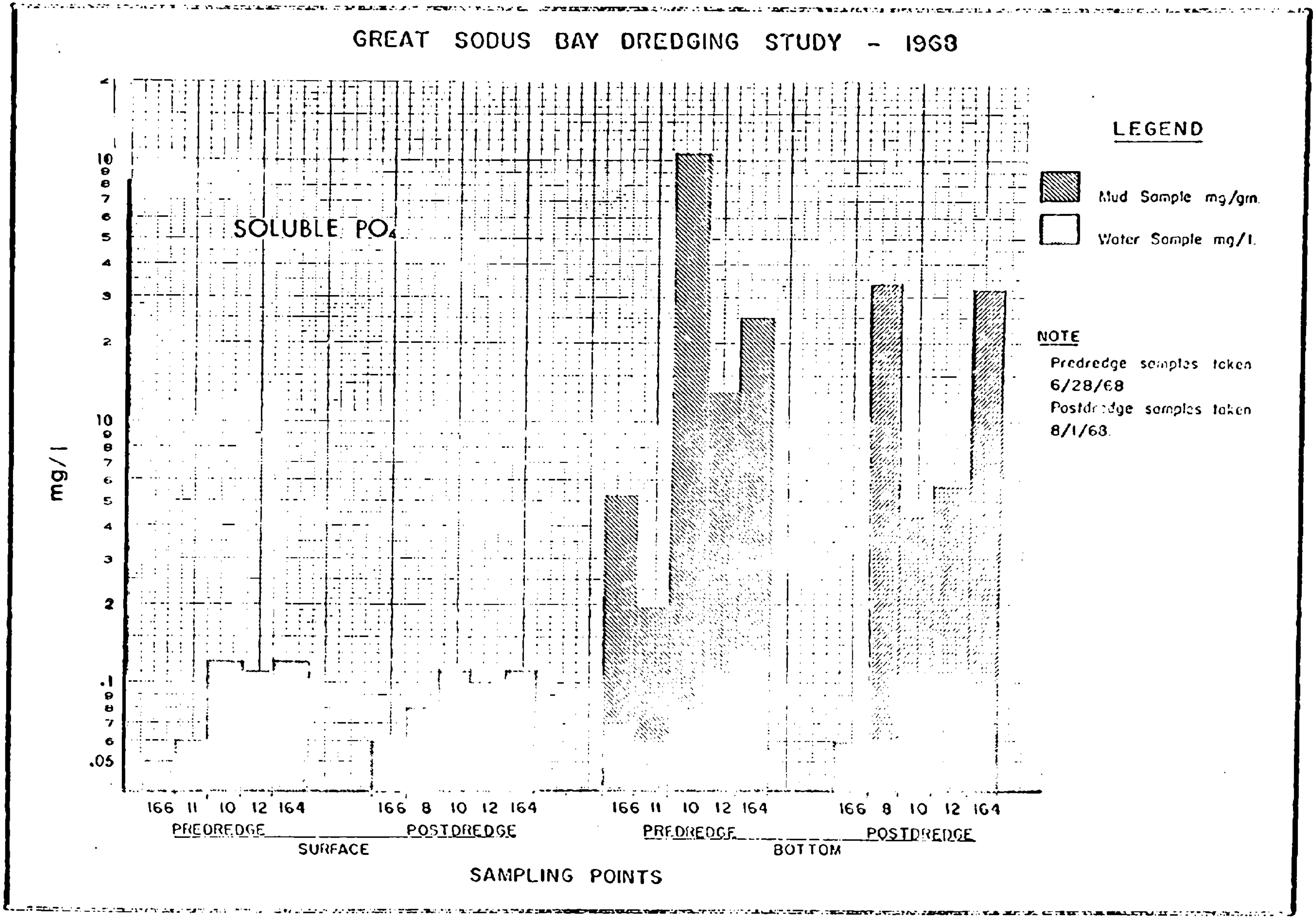

GREAT SODUS BAY DREDGING STUDY - 1968
SOLUBLE PO_4
mg/l
10
2
.1
.05
LEGEND
Mud Sample mg/gm.
Water Sample mg/l.
NOTE
Predredge samples taken 6/28/68
Postdredge samples taken 8/1/68.
166 11 10 12 164
PREDREDGE
166 8 10 12 164
POSTDREDGE
SURFACE
BOTTOM
SAMPLING POINTS

FIGURE 11

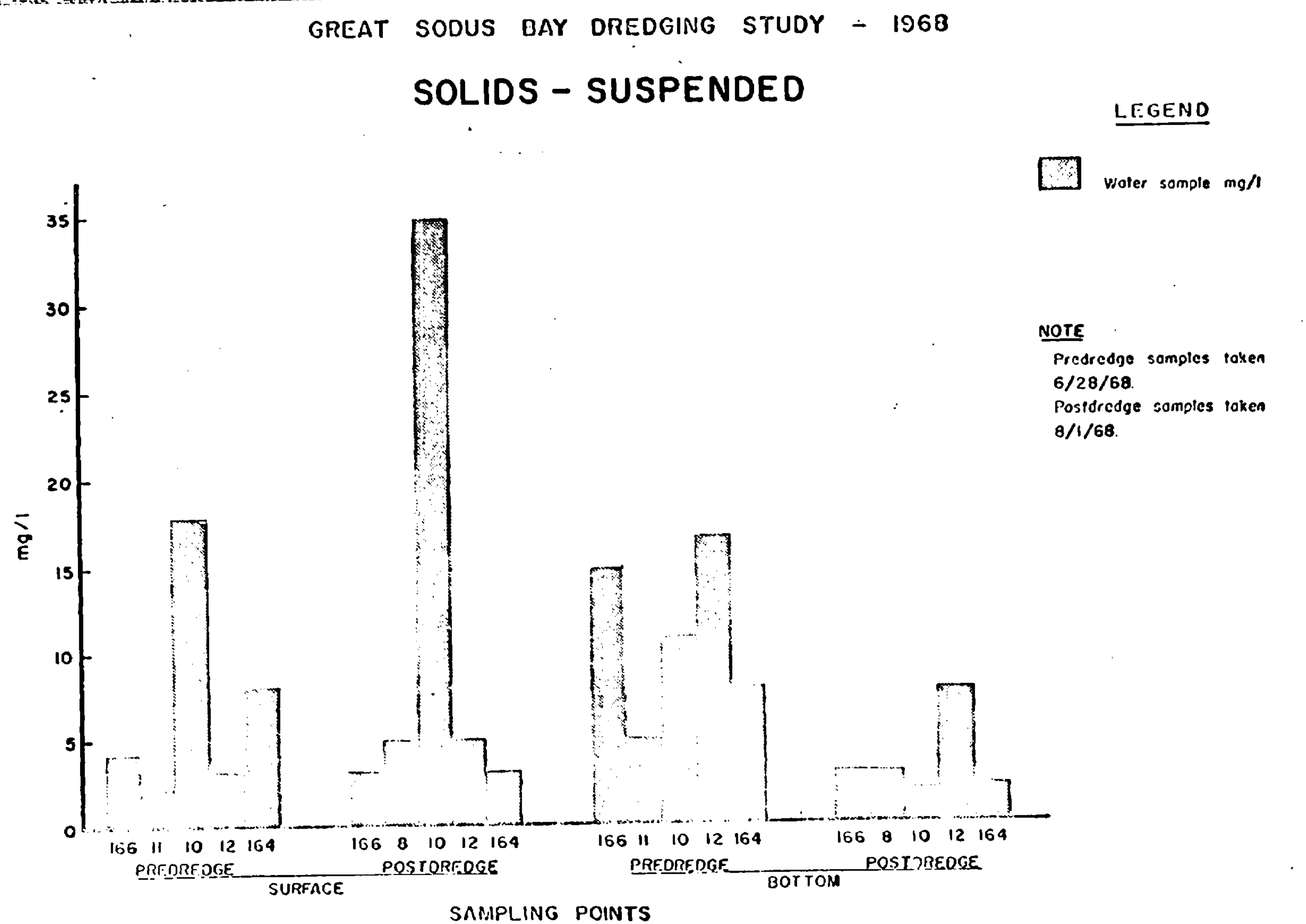
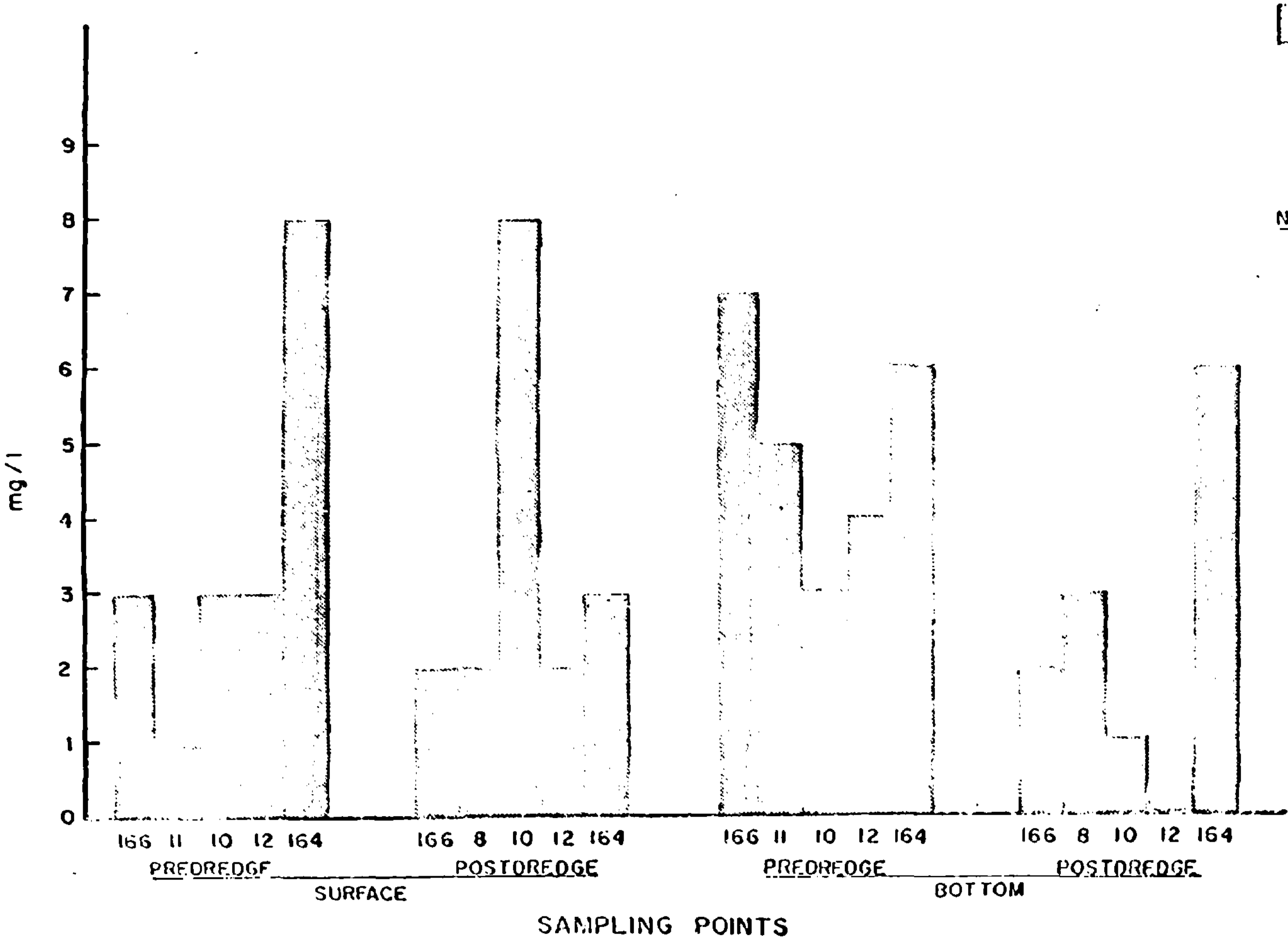

GREAT SODUS BAY DREDGING STUDY - 1968
SOLIDS - SUSPENDED
LEGEND
Water sample mg/l
NOTE
Predredge samples taken 6/28/68.
Postdredge samples taken 8/1/68.
mg/l
0
5
10
15
20
25
30
35
166 11 10 12 164
PREDREDGE
166 8 10 12 164
POSTDREDGE
SURFACE
166 11 10 12 164
PREDREDGE
166 8 10 12 164
POSTDREDGE
BOTTOM
SAMPLING POINTS

FIG 12

GREAT SODUS BAY DREDGING STUDY - 1968

SOLIDS - VOLATILE SUSPENDED



LEGEND

Water sample mg/l

NOTE

Predredge samples taken 6/28/68.

Postdredge samples taken 8/1/68.

FIG 13

GREAT SODUS BAY DREDGING STUDY - 1968

CHLORIDES

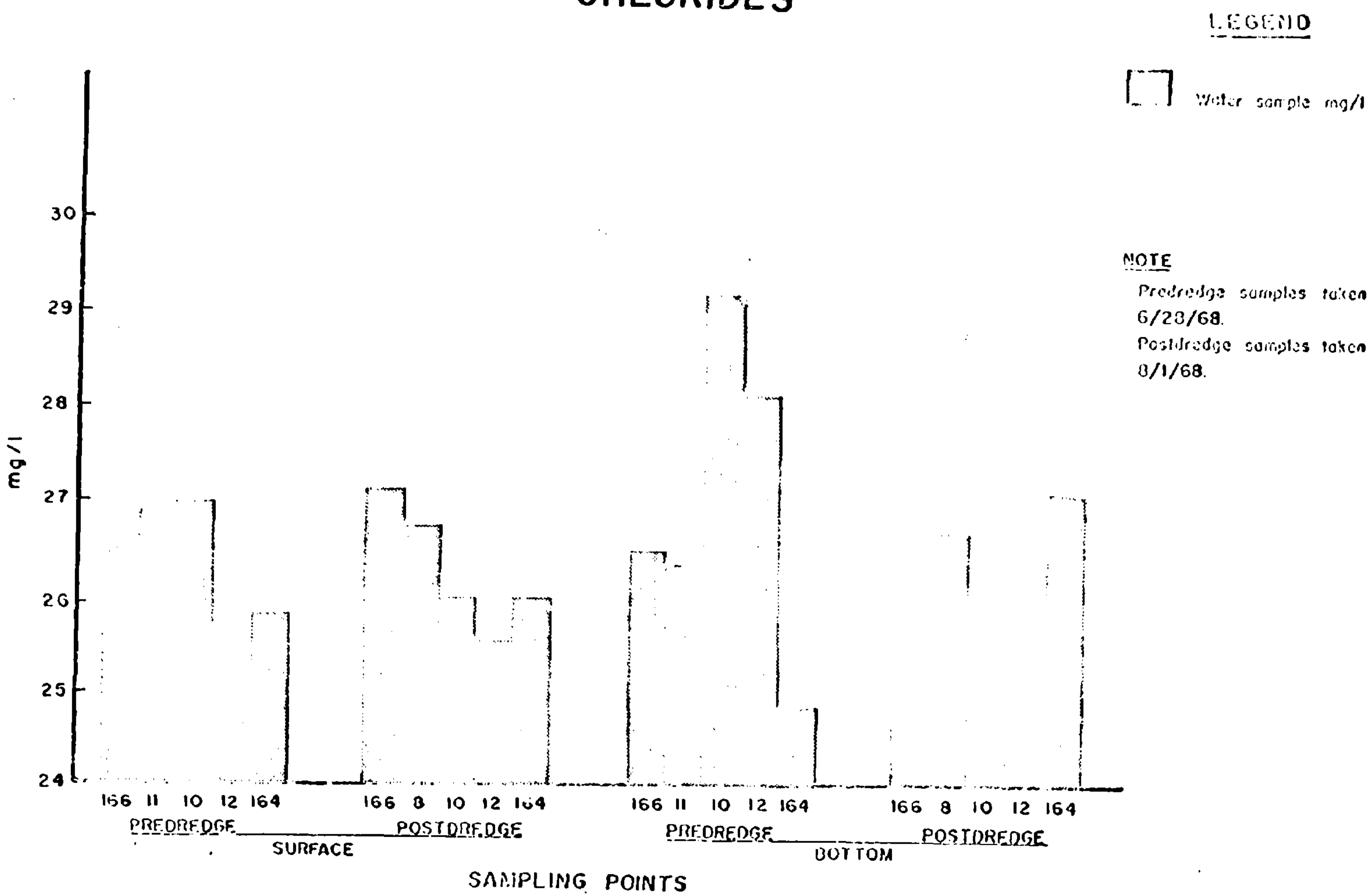


FIG 14

GREAT SODUS BAY DREDGING STUDY – 1968

ALKALINITY

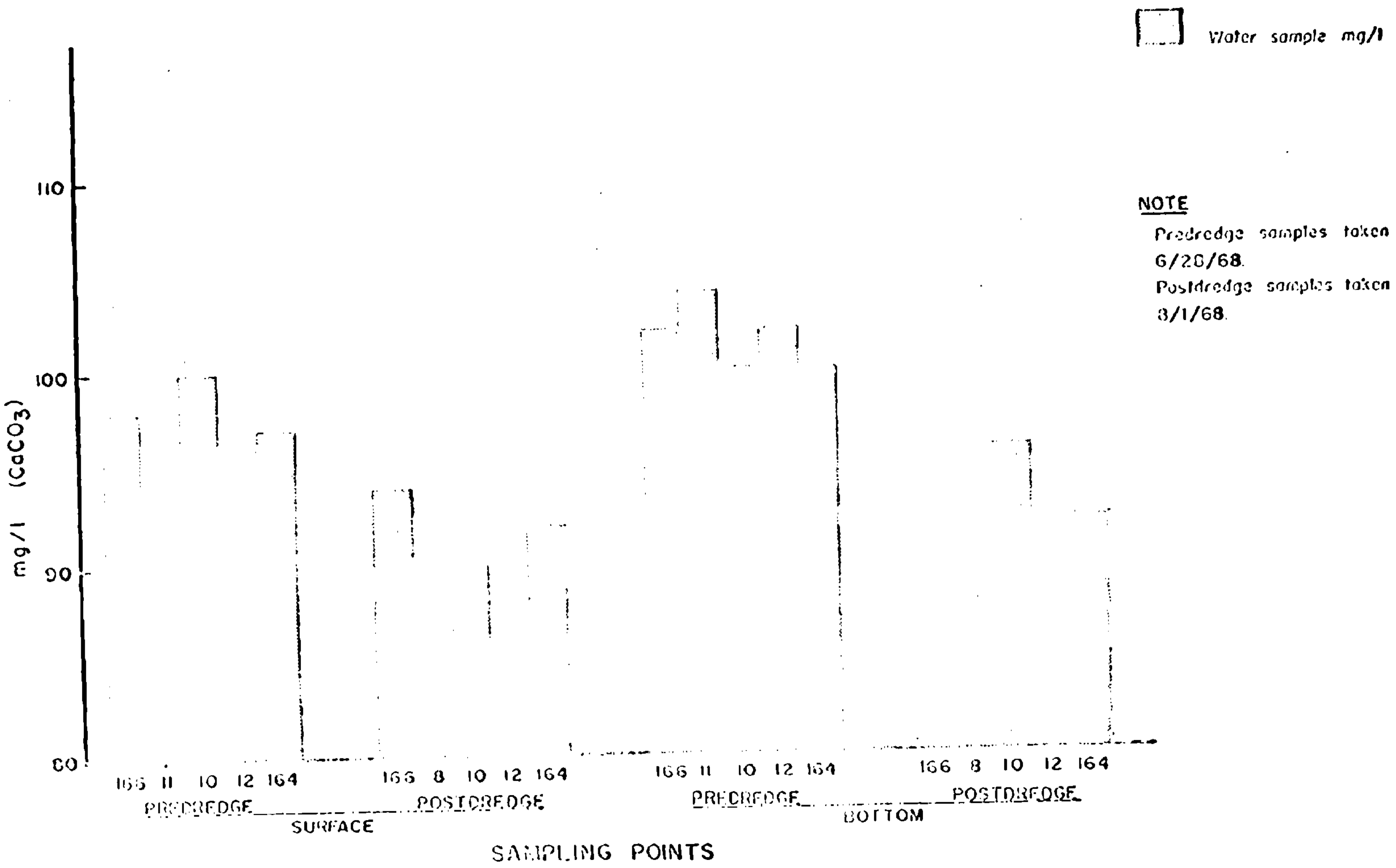


FIG 15

GREAT SODUS BAY DREDGING STUDY - 1968

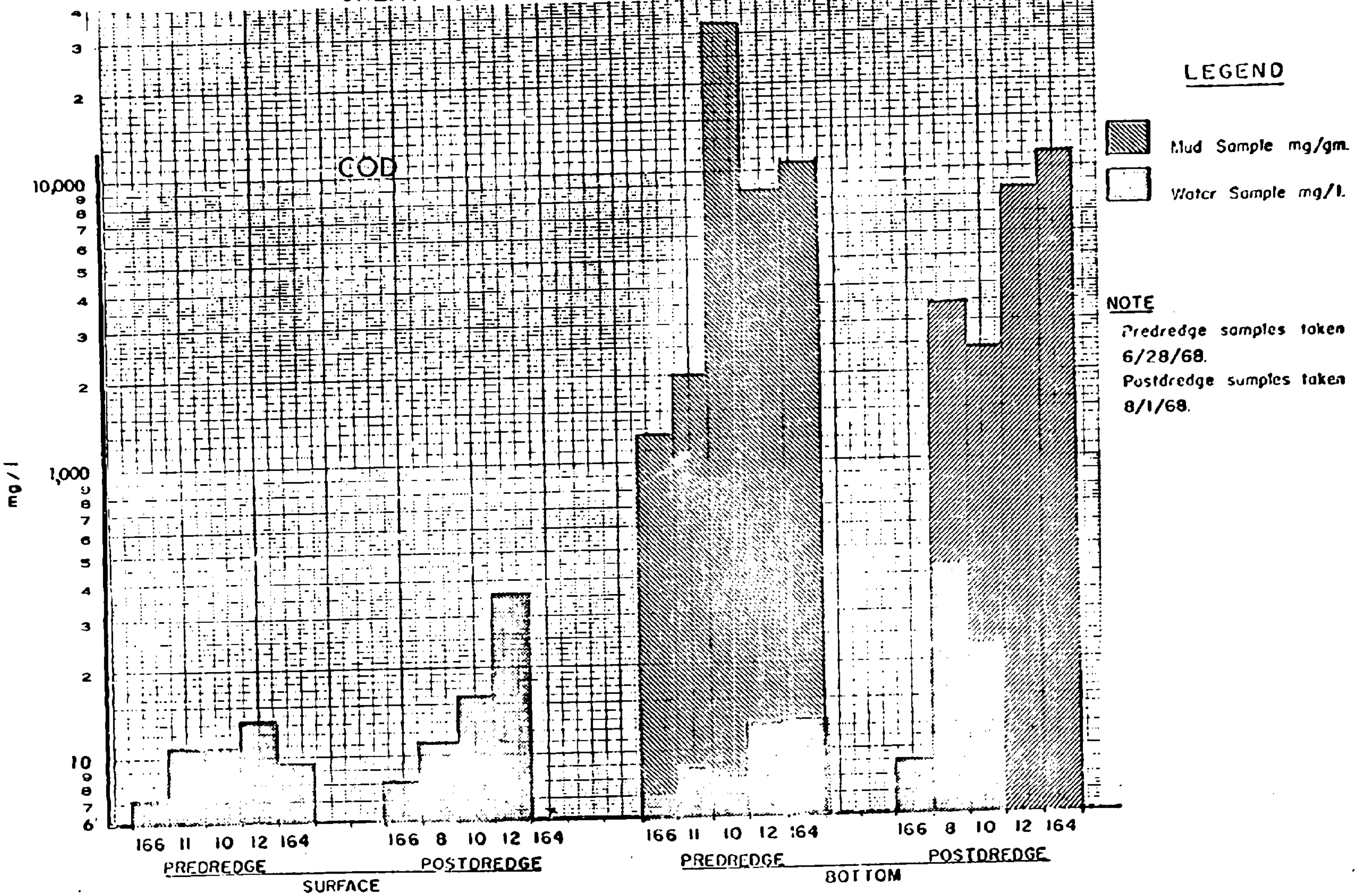
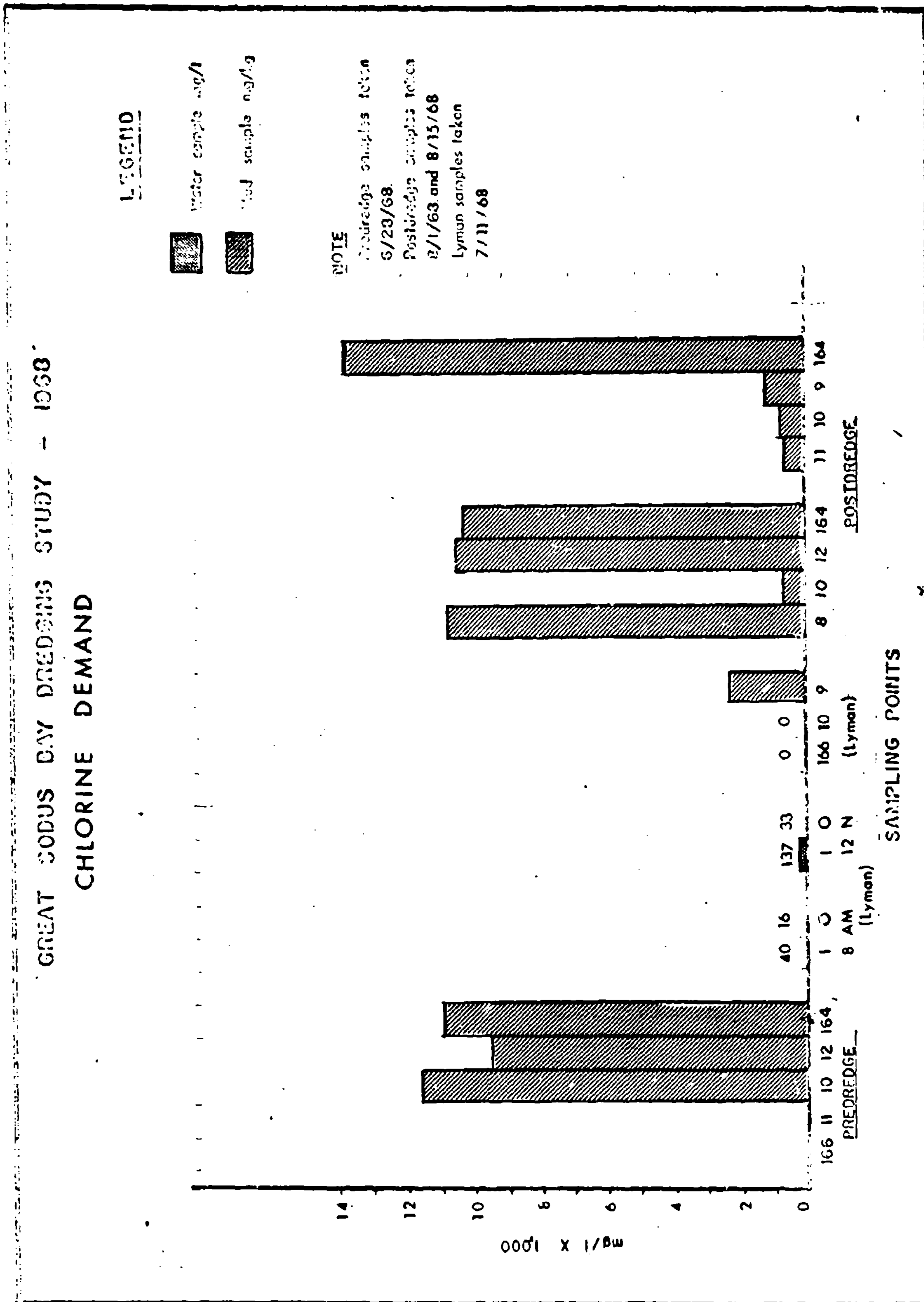
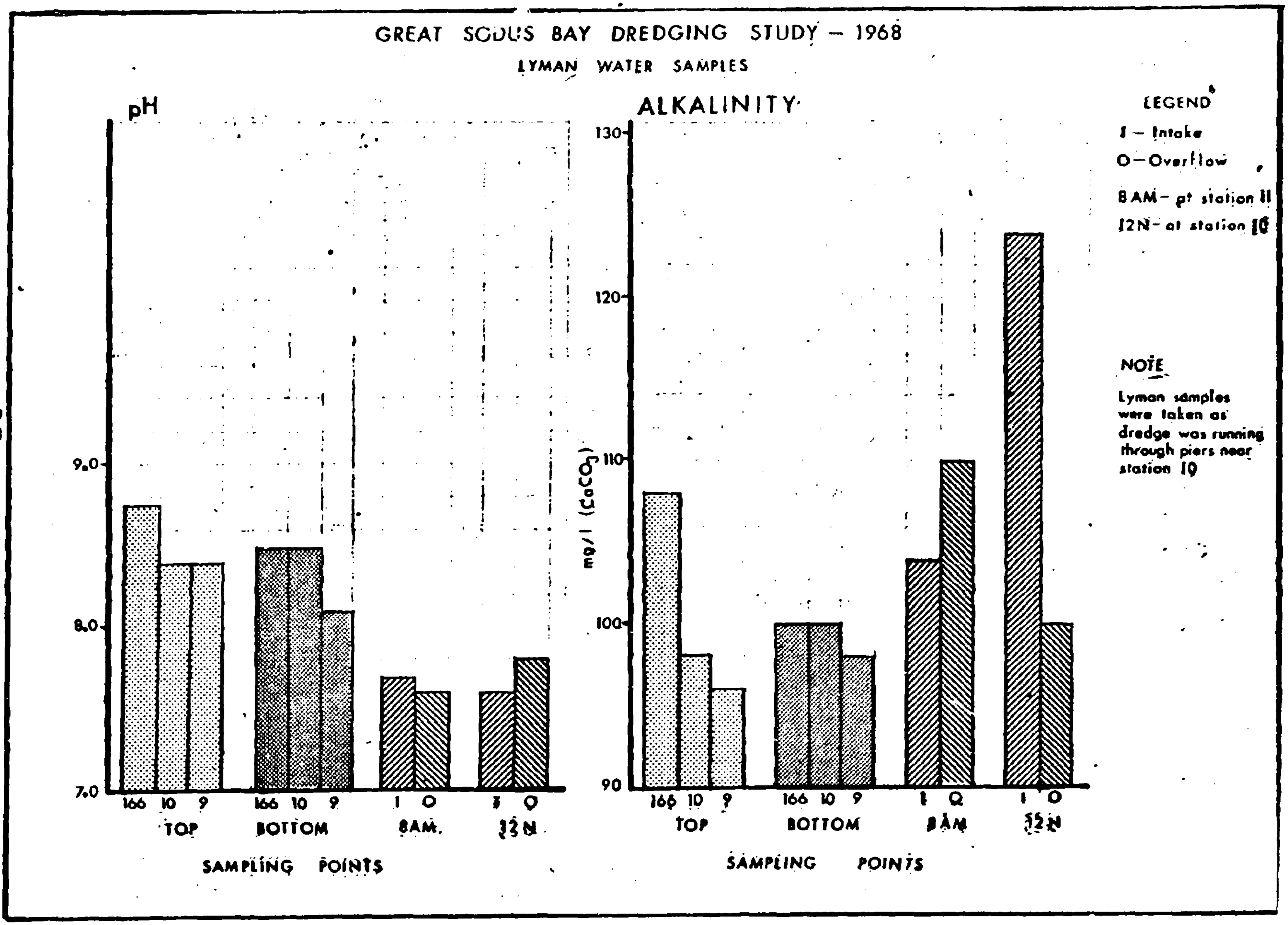


FIGURE 16



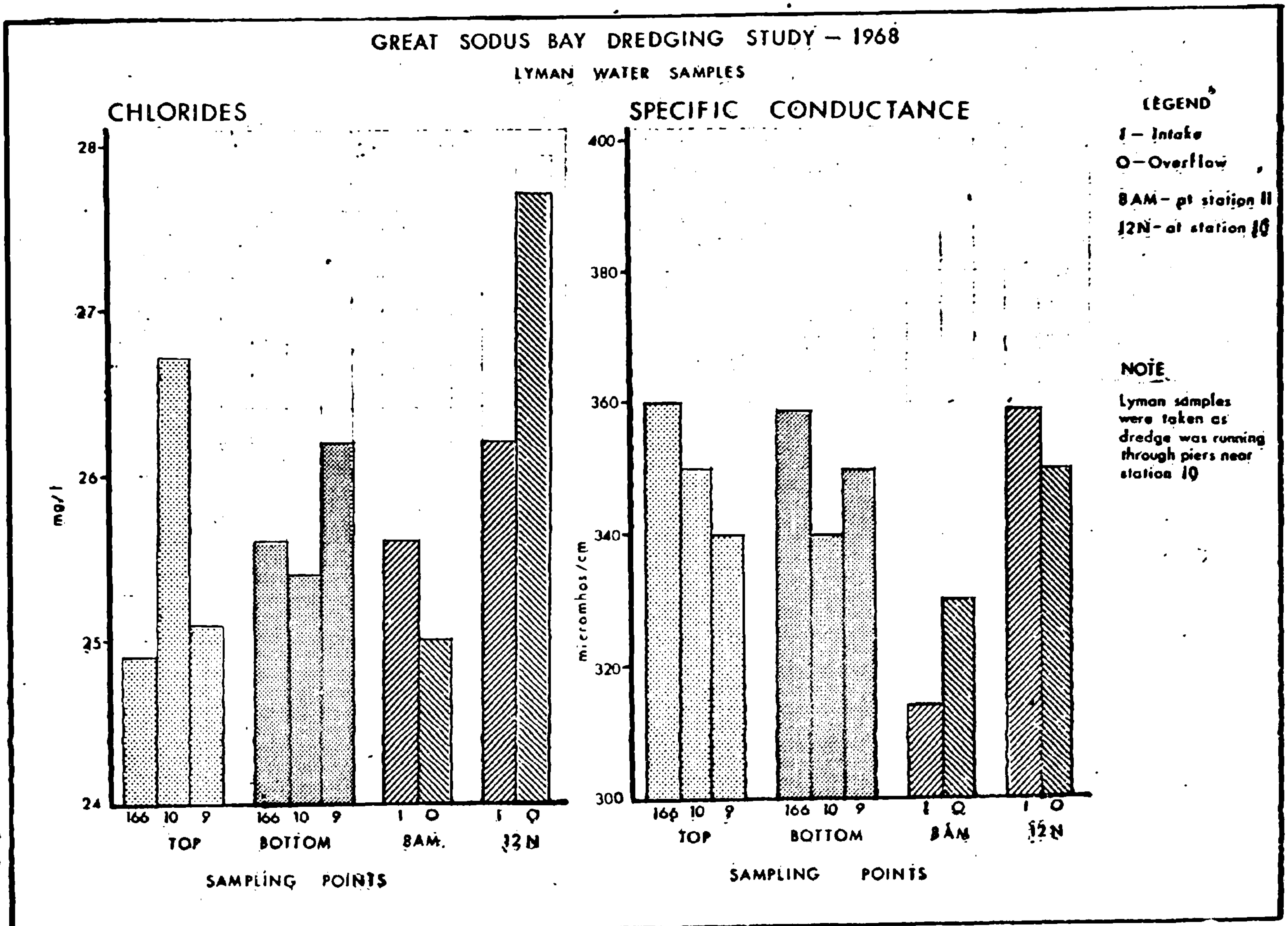
GREAT SODUS BAY DREDGING STUDY - 1968
CHLORINE DEMAND
LEGEND
Water sample mg/l
Mud sample mg/kg
NOTE
Predredge samples taken 6/23/68
Postdredge samples taken 8/1/68 and 8/15/68
Lyman samples taken 7/11/68
mg/l X 1000
14
12
10
8
6
4
2
0
40
16
137
33
0
0
166
11
10
12
164
1
0
8 AM
(Lyman)
1
0
12 N
166
10
9
(Lyman)
8
10
12
164
11
10
9
164
PREDREDGE
POSTDREDGE
SAMPLING POINTS

FIGURE 16A



GREAT SODUS BAY DREDGING STUDY – 1968
LYMAN WATER SAMPLES
pH
9.0
8.0
7.0
166 10 9
TOP
166 10 9
BOTTOM
I O
8AM.
I O
12N
SAMPLING POINTS
ALKALINITY
130
120
110
100
90
mg/l (CaCO3)
166 10 9
TOP
166 10 9
BOTTOM
I O
8AM
I O
12N
SAMPLING POINTS
LEGEND
I – Intake
O – Overflow
8AM – at station 11
12N – at station 10
NOTE
Lyman samples were taken as dredge was running through piers near station 10

FIGURE 17



GREAT SODUS BAY DREDGING STUDY – 1968
LYMAN WATER SAMPLES
CHLORIDES
mg/l
28
27
26
25
24
166 10 9
TOP
166 10 9
BOTTOM
I O
8AM.
I O
12 N
SAMPLING POINTS
SPECIFIC CONDUCTANCE
micromhos/cm
400
380
360
340
320
300
166 10 9
TOP
166 10 9
BOTTOM
I O
8AM
I O
12N
SAMPLING POINTS
LEGEND
I – Intake
O – Overflow
8AM – at station 11
12N – at station 10
NOTE
Lyman samples were taken as dredge was running through piers near station 10

FIGURE 18

GREAT SODUS BAY DREDGING STUDY - 1968

LYMAN WATER SAMPLES

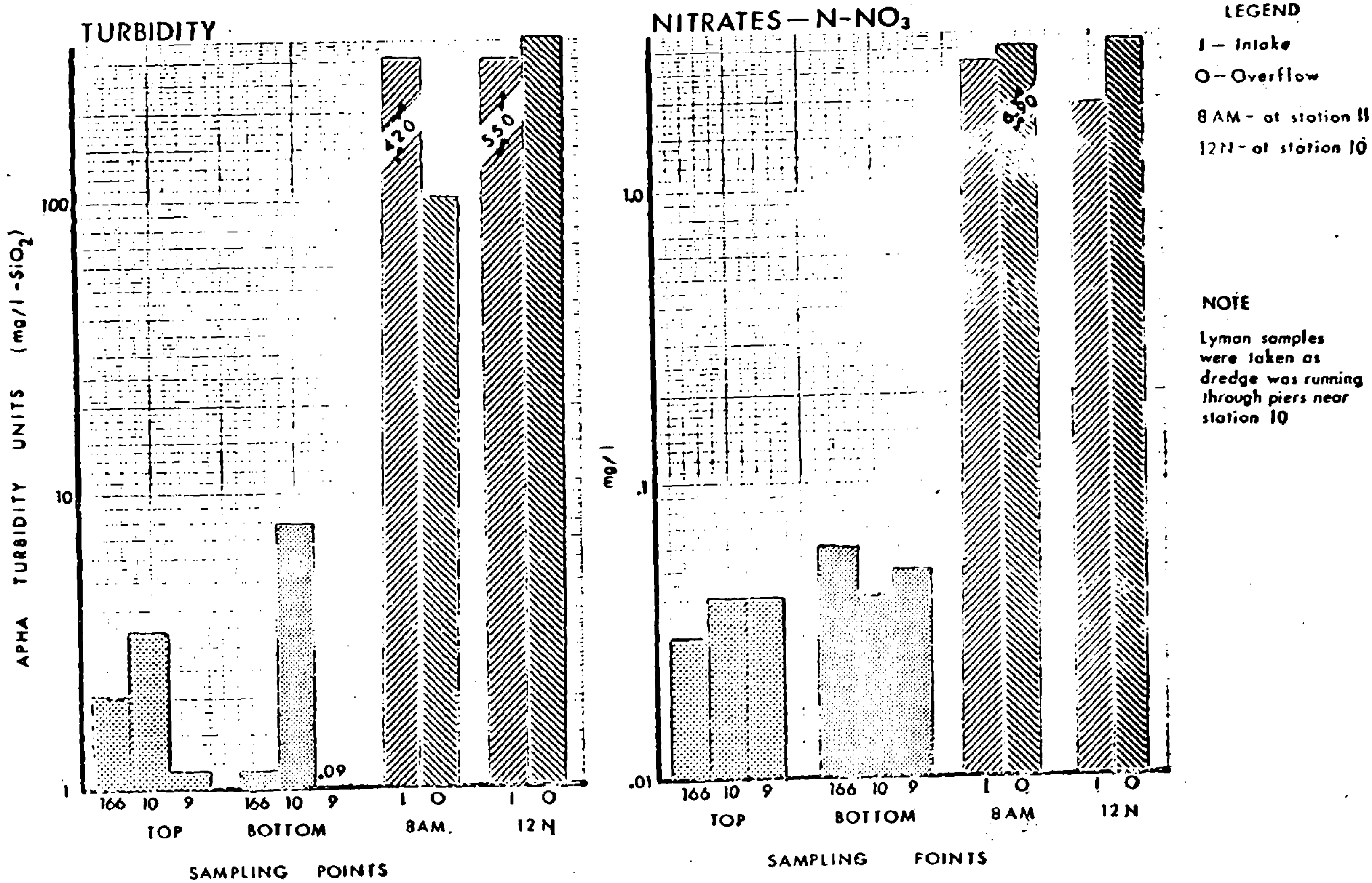


FIGURE 19

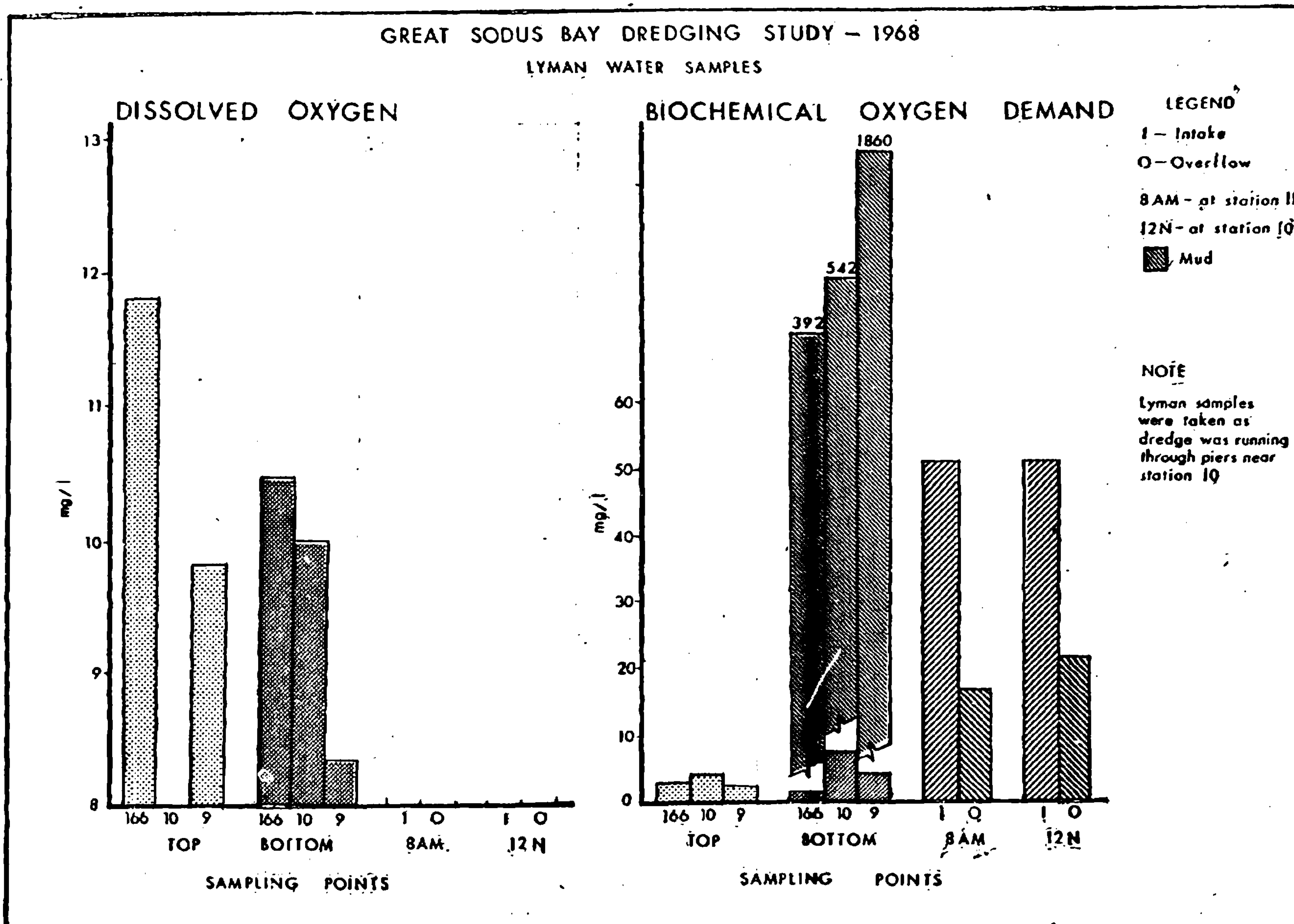

GREAT SODUS BAY DREDGING STUDY – 1968
LYMAN WATER SAMPLES
DISSOLVED OXYGEN
mg/l
13
12
11
10
9
8
166 10 9
TOP
166 10 9
BOTTOM
I O
8AM.
I O
12 N
SAMPLING POINTS
BIOCHEMICAL OXYGEN DEMAND
mg/l
60
50
40
30
20
10
0
1860
542
392
166 10 9
TOP
166 10 9
BOTTOM
I O
8AM
I O
12N
SAMPLING POINTS
LEGEND
I – Intake
O – Overflow
8AM – at station 11
12N – at station 10
Mud
NOTE
Lyman samples were taken as dredge was running through piers near station 10

FIGURE 20

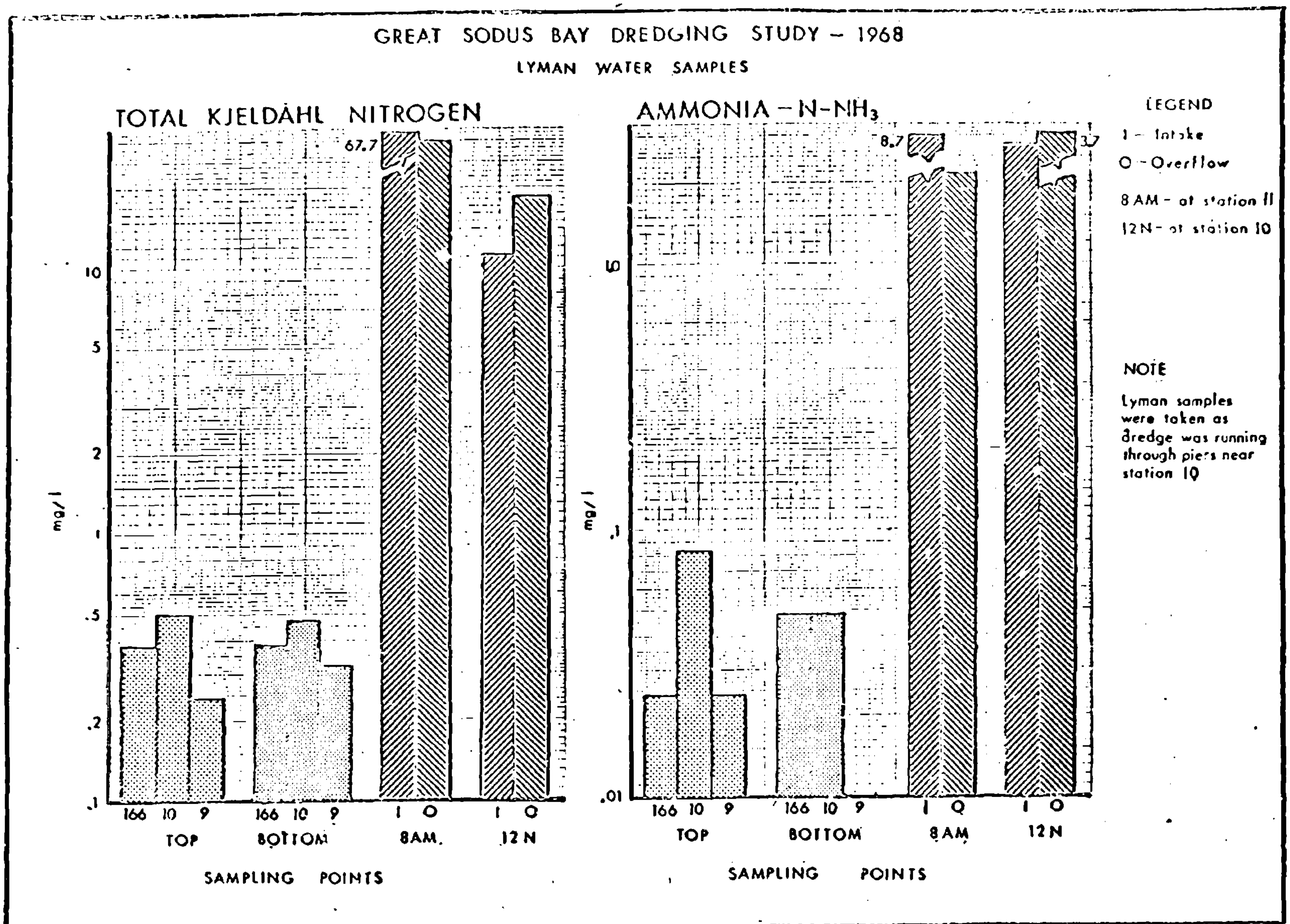

GREAT SODUS BAY DREDGING STUDY – 1968
LYMAN WATER SAMPLES
TOTAL KJELDAHL NITROGEN
AMMONIA – N-NH3
mg/l
10
5
2
1
.5
.2
.1
.01
67.7
8.7
3.7
166 10 9
TOP
BOTTOM
I O
8AM.
12 N
SAMPLING POINTS
LEGEND
I – Intake
O – Overflow
8 AM – at station 11
12N – at station 10
NOTE
Lyman samples were taken as dredge was running through piers near station 10

FIGURE 21

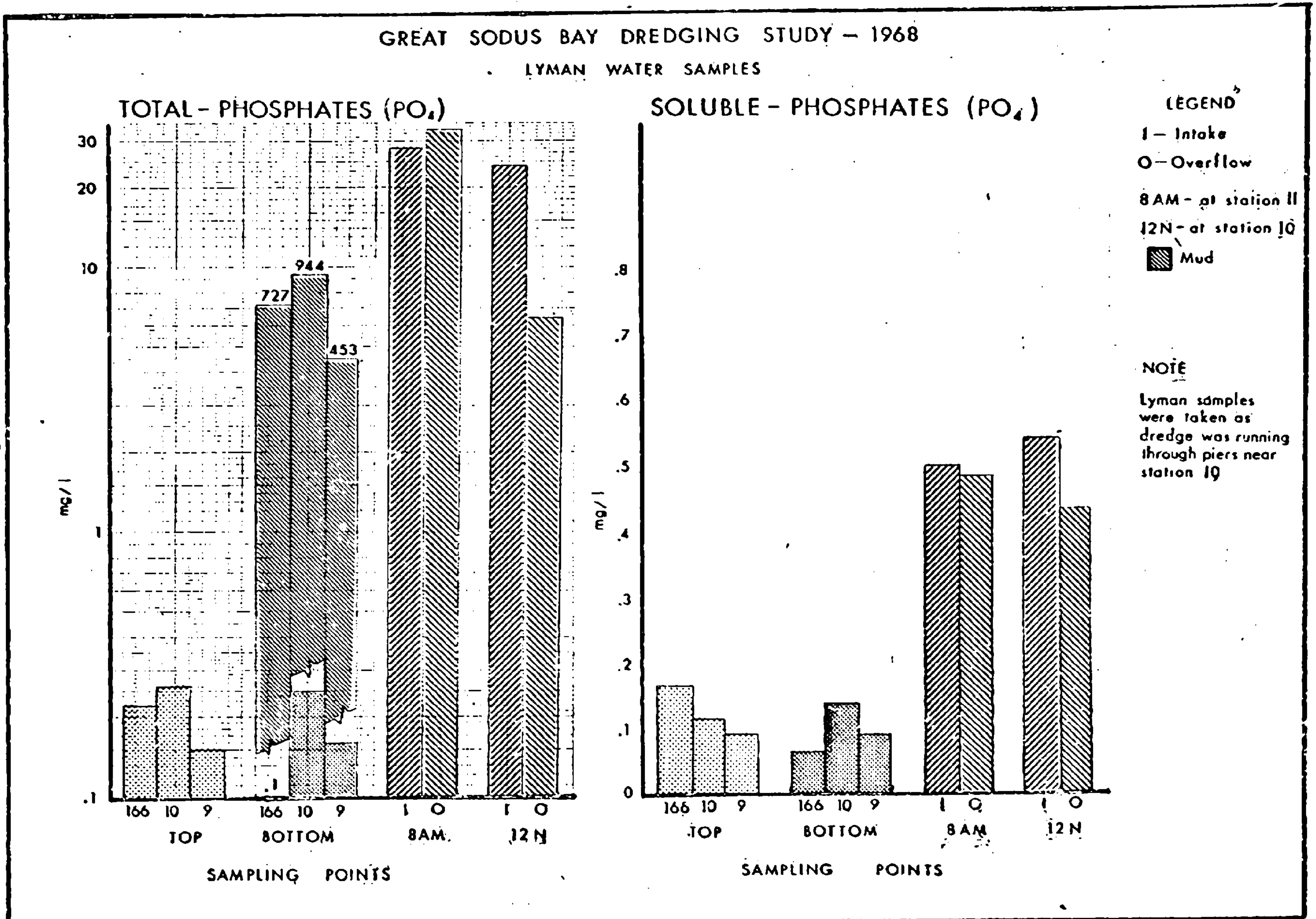

GREAT SODUS BAY DREDGING STUDY – 1968
LYMAN WATER SAMPLES
TOTAL - PHOSPHATES (PO4)
30
20
10
1
.1
mg/l
727
944
453
.1
166 10 9
TOP
166 10 9
BOTTOM
I O
8AM.
I O
12 N
SAMPLING POINTS
SOLUBLE - PHOSPHATES (PO4)
.8
.7
.6
.5
.4
.3
.2
.1
0
mg/l
166 10 9
TOP
166 10 9
BOTTOM
I O
8 AM
I O
12 N
SAMPLING POINTS
LEGEND
I – Intake
O – Overflow
8 AM - at station 11
12 N - at station 10
Mud
NOTE
Lyman samples were taken as dredge was running through piers near station 10

FIGURE 22

GREAT SODUS BAY DREDGING STUDY – 1968

LYMAN WATER SAMPLES

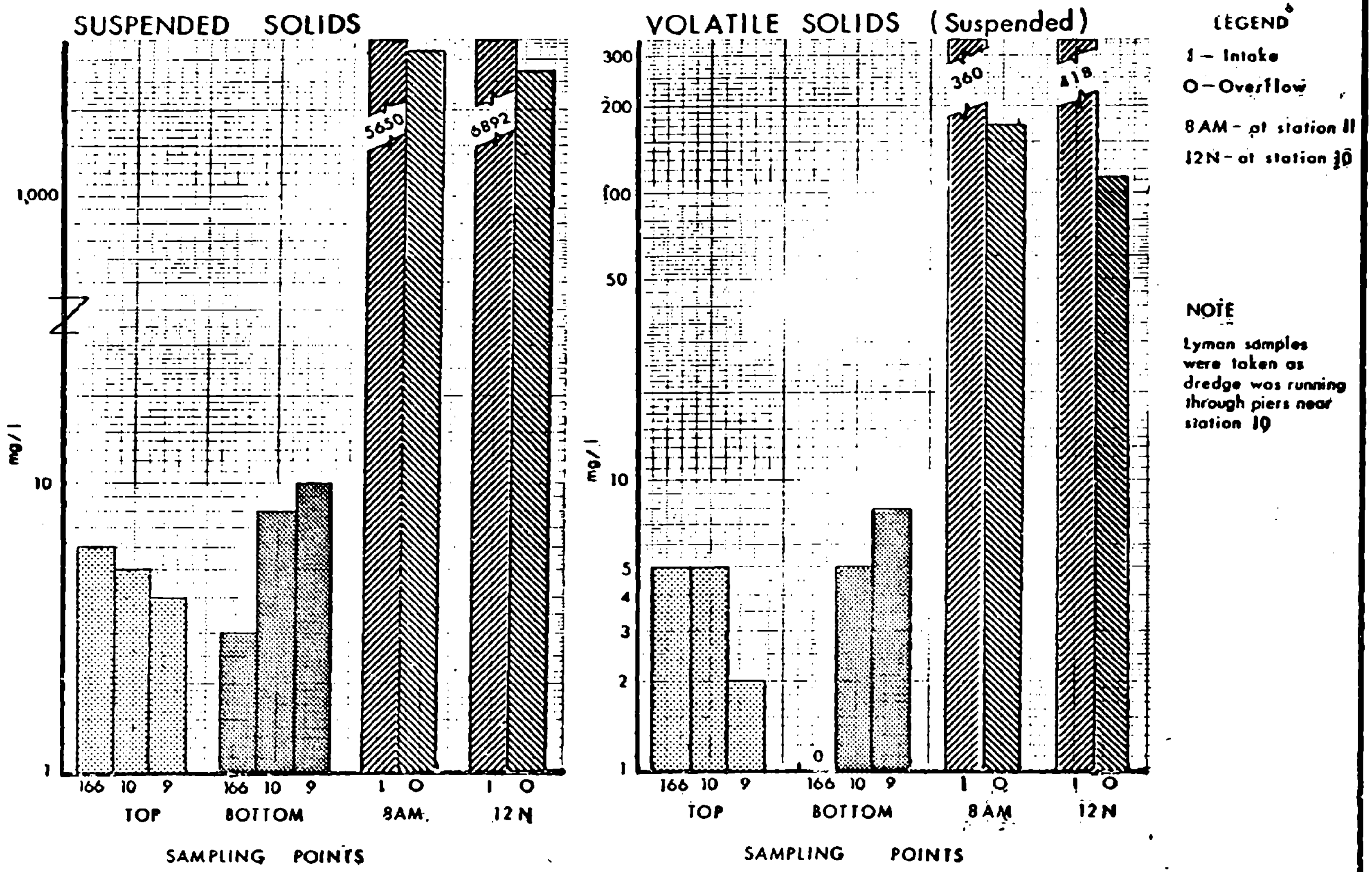


FIGURE 23

APPENDIX A3

INTERIM SUMMARY
of
BUFFALO HARBOR DREDGING EFFECTS INVESTIGATION

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
CLEVELAND PROGRAM OFFICE

March 1968

INTERIM SUMMARY OF BUFFALO
HARBOR DREDGING EFFECTS INVESTIGATION

March 1967

INTRODUCTION

This interim summary of the Buffalo Harbor dredging investigation includes data on in-place materials (sediment and water) sampled prior to dredging of the Buffalo Harbor, Buffalo River, and Black Rock Channel. Summary data on the concentration of constituents present in the inflow and outflow of the hopper dredges during dredging of the Buffalo Harbor and Black Rock Channel are also included.

The investigation in the Buffalo Harbor is directed towards determining the quality characteristics of the materials dredged, local effects of dredging in the dredging areas, and evaluating the efficacy of depositing the materials dredged from the Buffalo River into a sector enclosed by a dike constructed of steel plant slag.

It is not planned to investigate the effects on Lake Erie from the disposal of Buffalo Harbor dredgings into the lake. Such a study in this area would be inconclusive since any effects would largely be obscured by wastes from Bethlehem Steel and other industries currently entering Lake Erie in the immediate vicinity of the dump area.

Unavoidable delays in the construction of the dike severely limited the extent of sampling during and following completion of the Buffalo River dredging. Although some very preliminary indications of the suitability of disposal within the dike area have been obtained, data to be collected prior to 1968 dredging are needed to reach more valid conclusions.

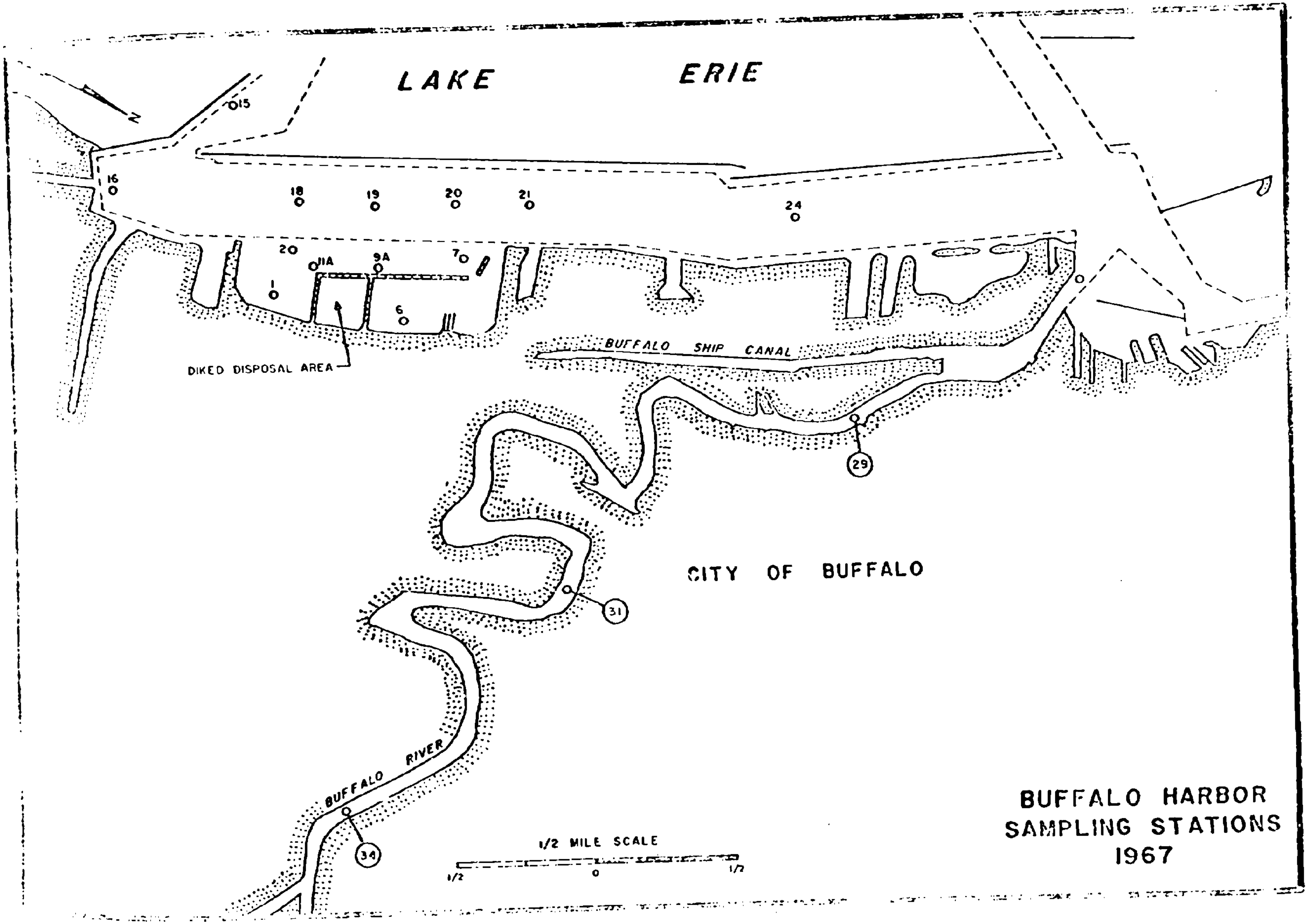
This summary is based principally upon sampling of bottom sediments and overlying water in the Buffalo River, Harbor and Black Rock Channel. Relatively few in-place sediment samples were collected in the Buffalo River. It is planned to more definitely determine the characteristics of these sediments from samples collected of the dredged material loaded on barges. These samples are currently being analyzed. Figures 1 and 2 show the sampling points.

Sediment Analysis

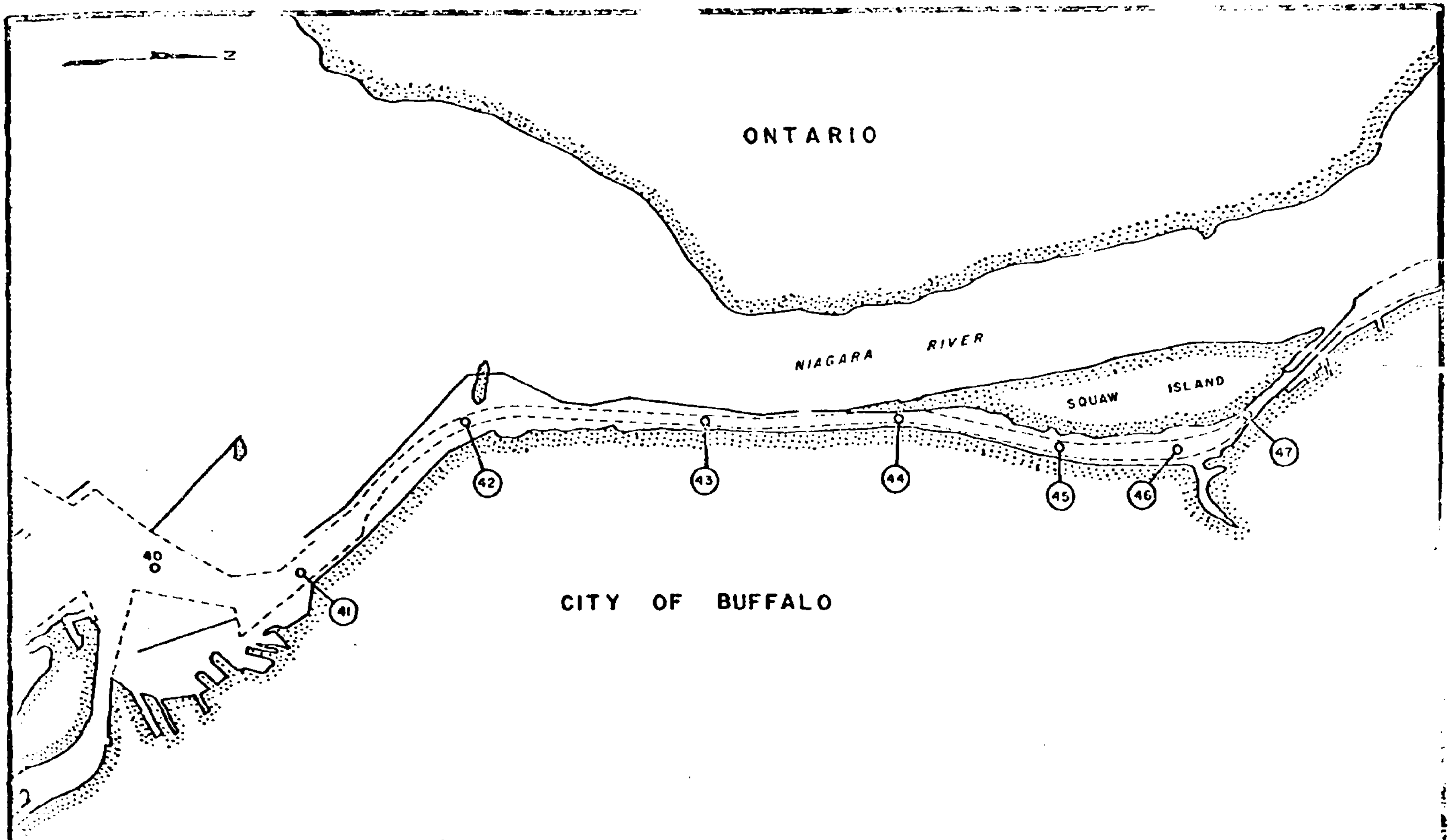
Figures 3 through 6 show the results of sediment analysis as value profiles for the river, harbor, and the Black Rock Channel.

Chemical Oxygen Demand

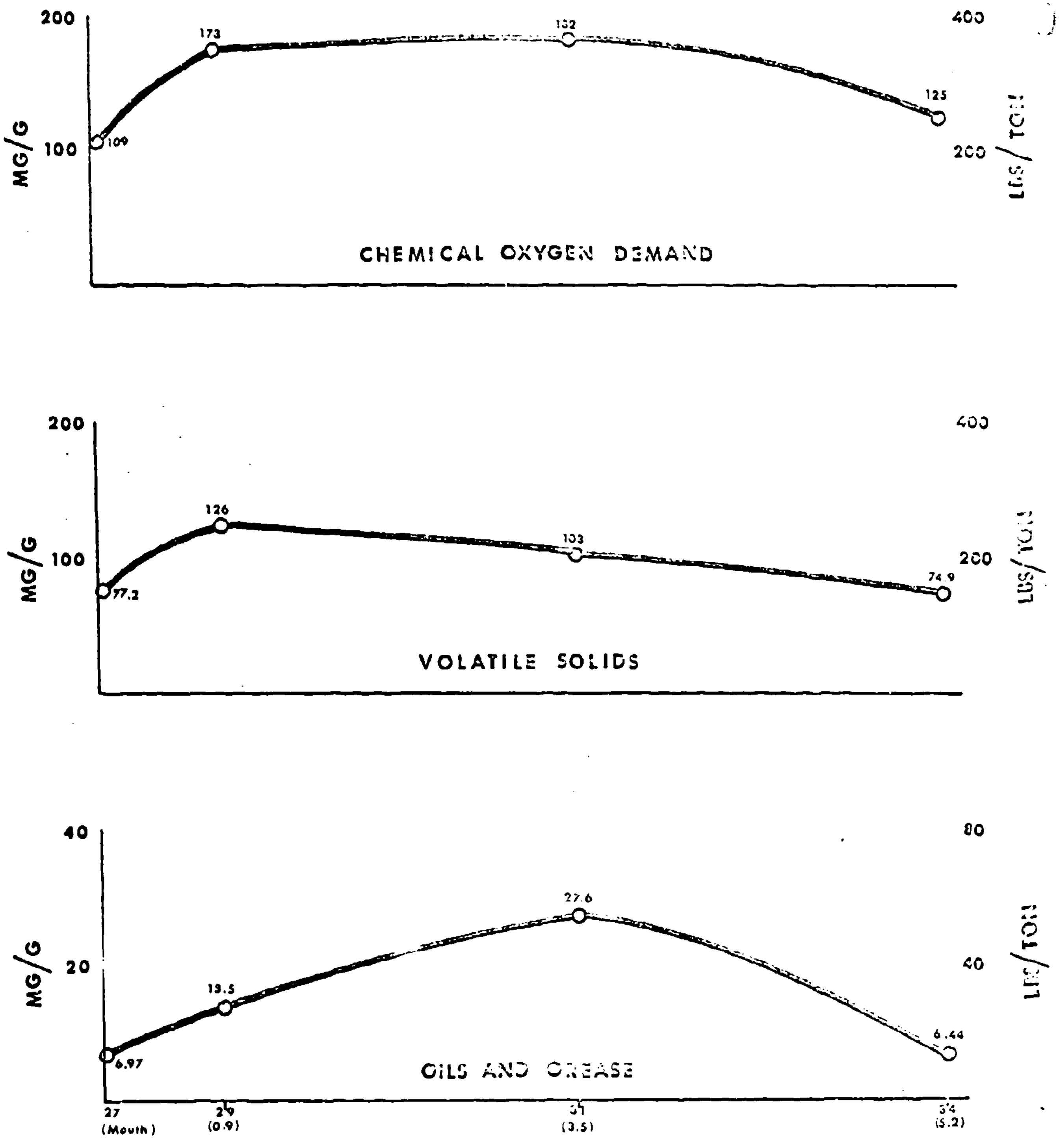
The Chemical Oxygen Demand (COD) of the harbor and channel is shown in Figures 3 and 5. The COD exceeded 100 mg/g at the south end of the harbor and decreases towards the north end of the harbor. Ferrous iron wastes from the Bethlehem Steel and Hanna Furnace plants most probably account for the higher concentration at the south end of the harbor. The mouth of the Buffalo River is at the extreme north end of the outer harbor. The flow from the river moves north into the Niagara River and the Black Rock Channel. The increase of COD in the sediments from the south end to the north portion of the channel most probably reflects the inputs from the Buffalo River together with inputs from Scajaquada Creek which enters at the north end of the channel. The maximum COD (218 mg/l) was found at the north end of the channel.



BUFFALO HARBOR
SAMPLING STATIONS
1967



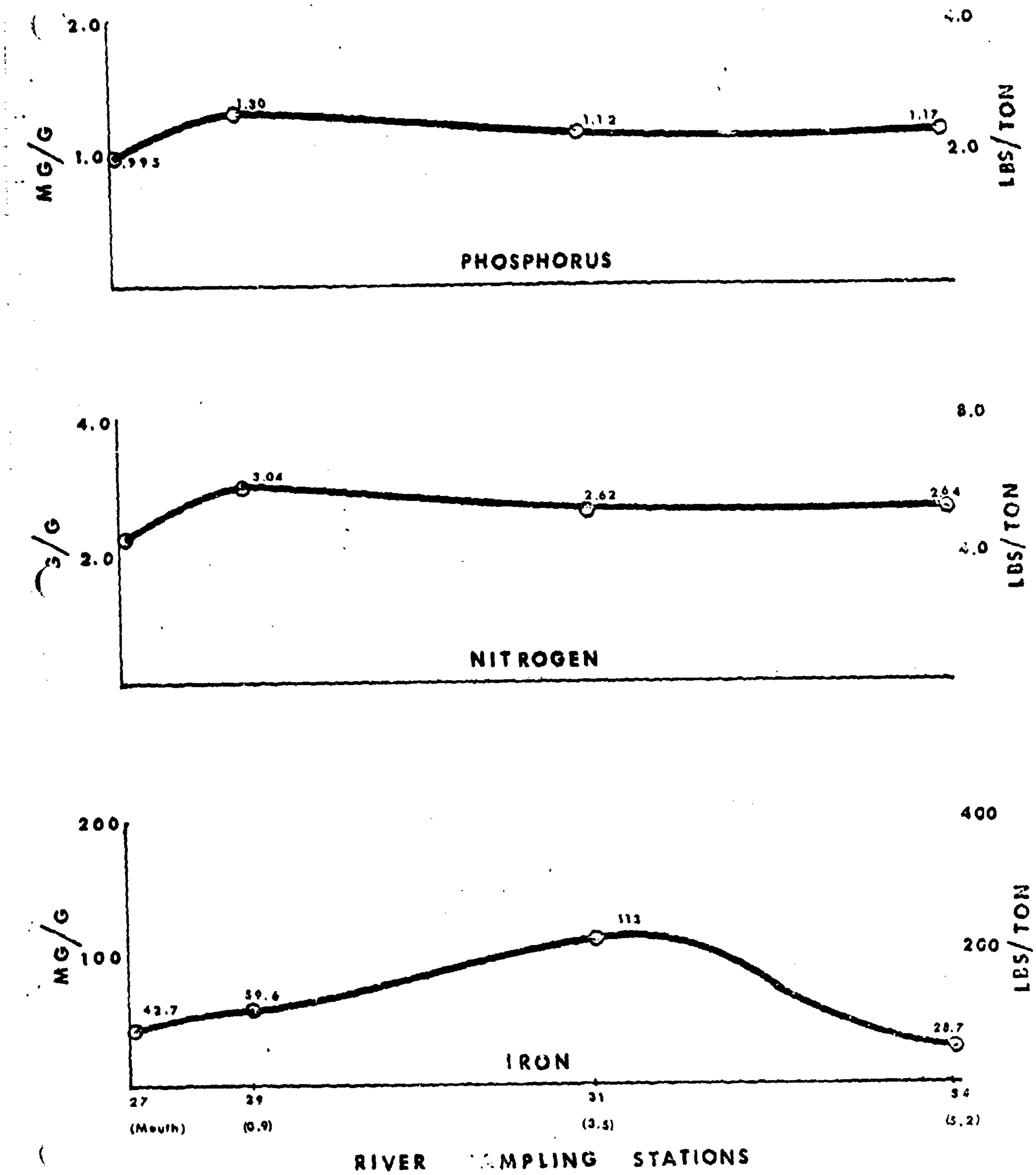
BUFFALO HARBOR
SAMPLING STATIONS
1967



N — Station No.
(N) — Miles Above Mouth

BUFFALO RIVER SEDIMENT DATA

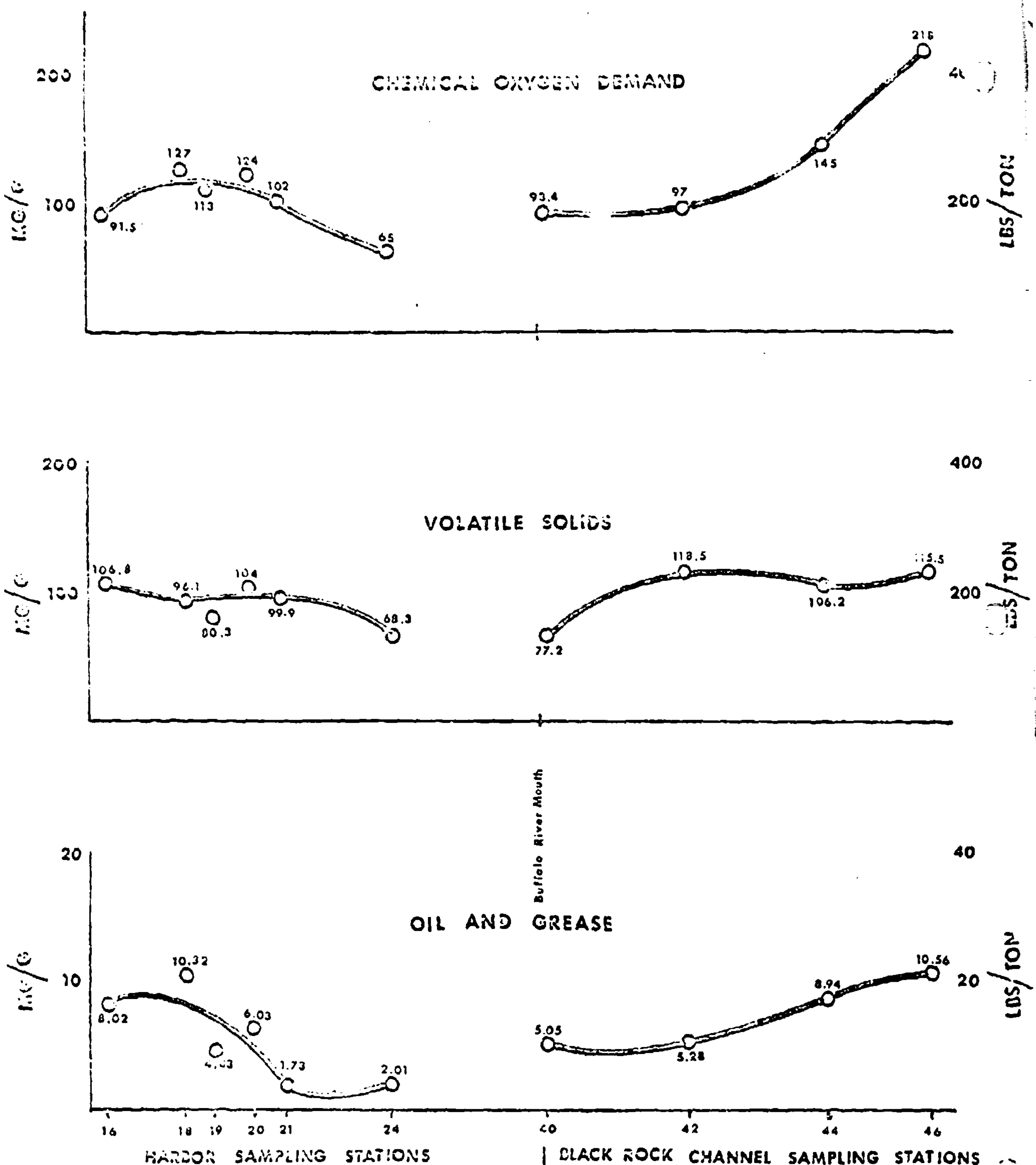
Figure 3



BUFFALO RIVER SEDIMENT DATA

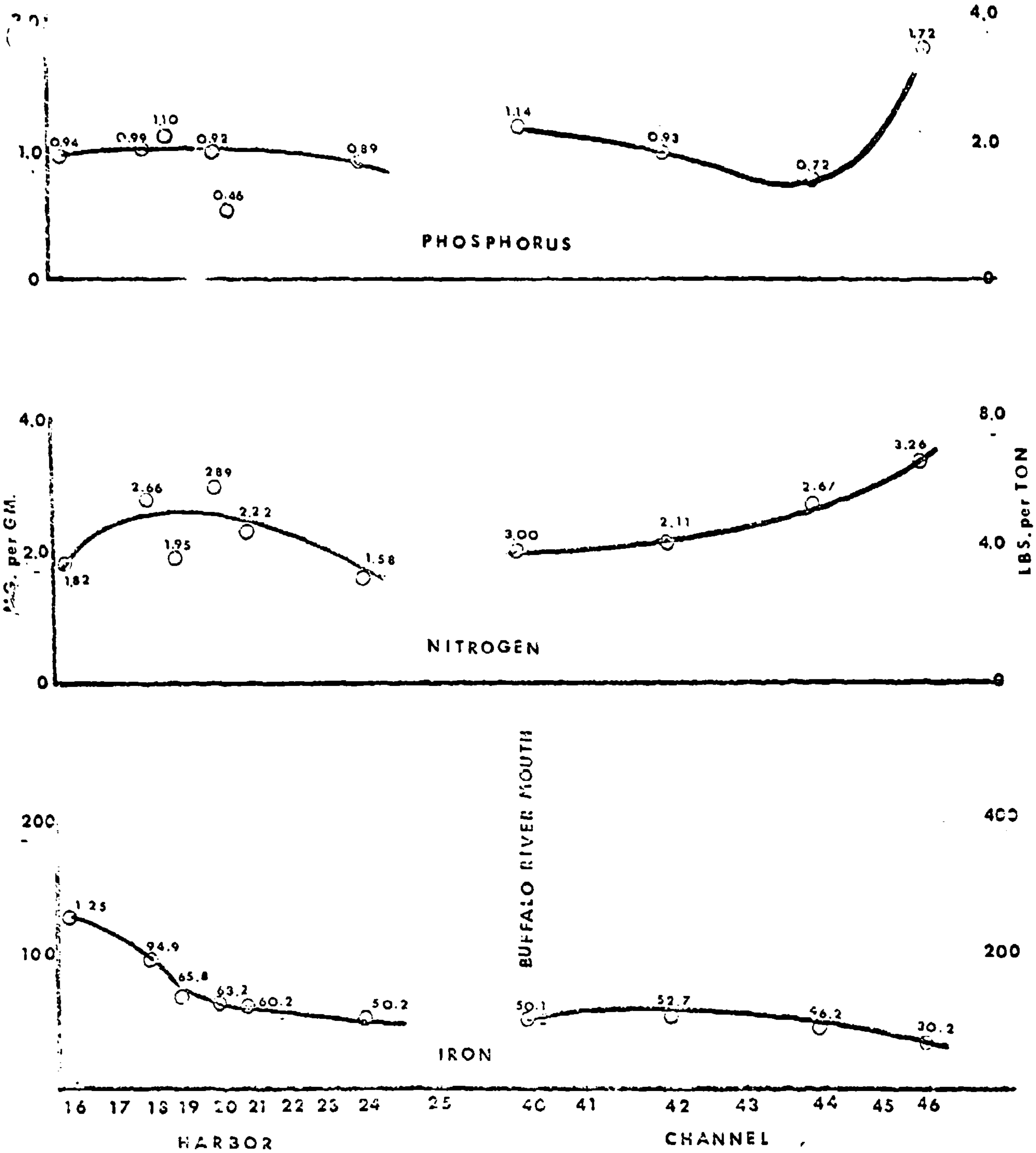
N-Station No.
(N)-Miles Above Mouth

Figure 4



BUFFALO HARBOR AND BLACK ROCK CHANNEL SEDIMENT DATA

Figure 5



BUFFALO HARBOR AND BLACK ROCK CHANNEL SEDIMENT CHEMICAL CONCENTRATIONS

Figure 6

The limited Buffalo River data indicates that the COD of the sediments is lowest at the upstream limit of the dredged sector and increases downstream to 180 mg/g in the vicinity of several industrial waste discharges. It decreases markedly at the river mouth where significant dilution with lake water occurs.

Volatile Solids

The concentration of volatile solids in the sediments (Figure 3) followed a distribution pattern similar to that of the COD. The maximum concentrations were 107 mg/g at the south end of the harbor, 119 mg/g in the channel and 126 mg/g at the lower end of the Buffalo River.

Oil and Grease

Concentrations of 10 mg/g of oil and grease (hexane extractables) were found at the south end of the harbor and the north end of the channel. Quantities as low as 1.73 mg/g were found in the intermediate sectors. The concentration ranged from approximately 7 mg/g at the upper limit of dredging and at the mouth of the Buffalo River to a maximum of 27.6 mg/g near the center of the dredged portion.

Phosphorus

The amount of phosphorus in the sediments was about 1 mg/g throughout the harbor and channel except at the north end of the channel where it was 1.72 mg/g. The higher value found at this location probably results from combined sewer overflows to Scajaquada Creek. The concentrations in the Buffalo River were also relatively constant, ranging from 1.0 to 1.3 mg/g.

Nitrogen

The total nitrogen level in the sediments was higher at the south end of the harbor (2.89 mg/g) and at the north end of the channel (3.26 mg/g) than at any intermediate point sampled. The concentration was somewhat more uniform in the Buffalo River, ranging from 2.2 mg/g to 3 mg/g found 0.9 miles upstream of the mouth.

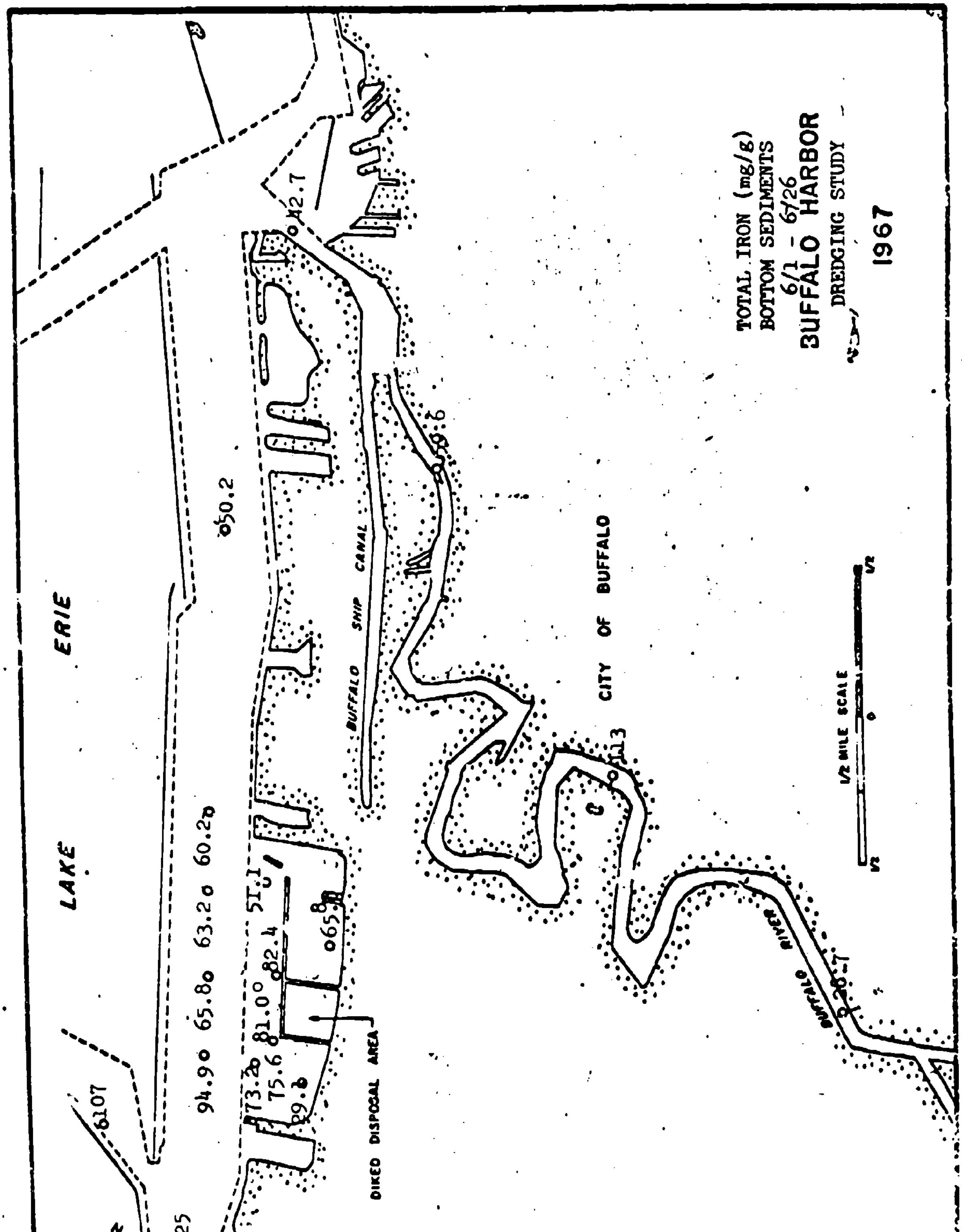
Iron

The maximum concentration of 125 mg/g of iron was found at the north end of the harbor which receives iron bearing wastes from the Hanna Furnace and Bethlehem Steel plants. In other portions of the harbor and channel the sediments contained about 50 mg/g of iron.

As was expected, the maximum concentration of iron (113 mg/g in the Buffalo River was found near steel plant waste discharges. It was approximately 29 mg/g at the upper dredging limit and 49 mg/g at the mouth.

Diked Area for Disposal of Buffalo River Dredgings

Figures 7 through 12 show the concentration of the various constituents in the sediments in the vicinity of the diked disposal area as well as the harbor and the Buffalo River. It is noted that the concentrations of total phosphorus, total nitrogen, and volatile solids were essentially the same near the diked sector as in the adjacent harbor area. The quantity of COD, iron, and oil and grease is somewhat lower in the immediate vicinity of the diked area than in the nearby harbor sector. This would seem to indicate that the movement and deposition of waste materials from the Bethlehem Steel and



TOTAL IRON (mg/g)
BOTTOM SEDIMENTS
6/1 - 6/26
BUFFALO HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF BUFFALO
BUFFALO SHIP CANAL
BUFFALO RIVER
DIKED DISPOSAL AREA
1/2 MILE SCALE

Figure 7

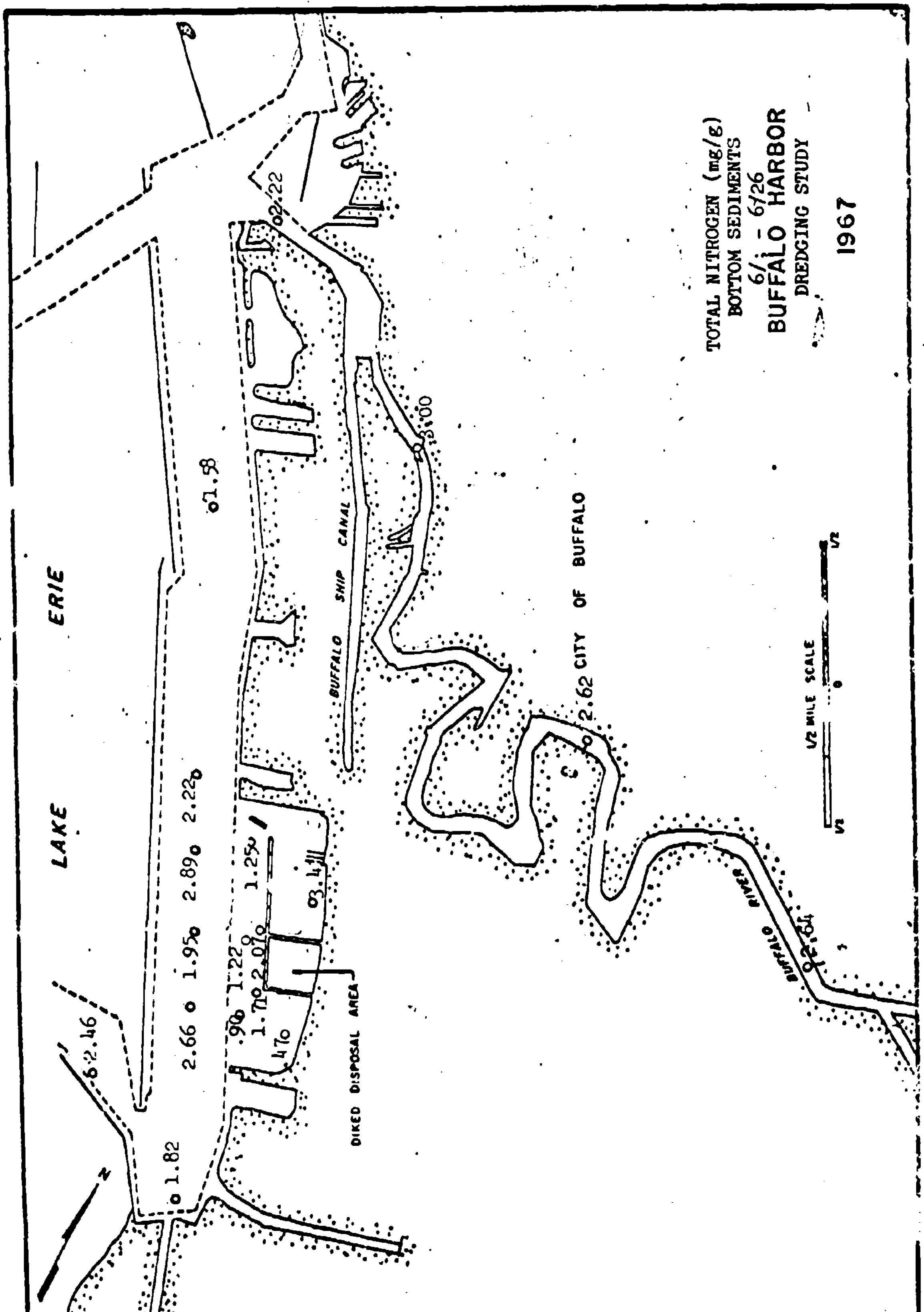

TOTAL NITROGEN (mg/g)
BOTTOM SEDIMENTS
6/1 - 6/26
BUFFALO HARBOR
DREDGING STUDY
1967
LAKE ERIE
BUFFALO SHIP CANAL
CITY OF BUFFALO
BUFFALO RIVER
DIKED DISPOSAL AREA
1/2 MILE SCALE
2.22
1.58
3.00
2.62
2.66
1.95
2.89
2.22
1.82
2.46

Figure 8

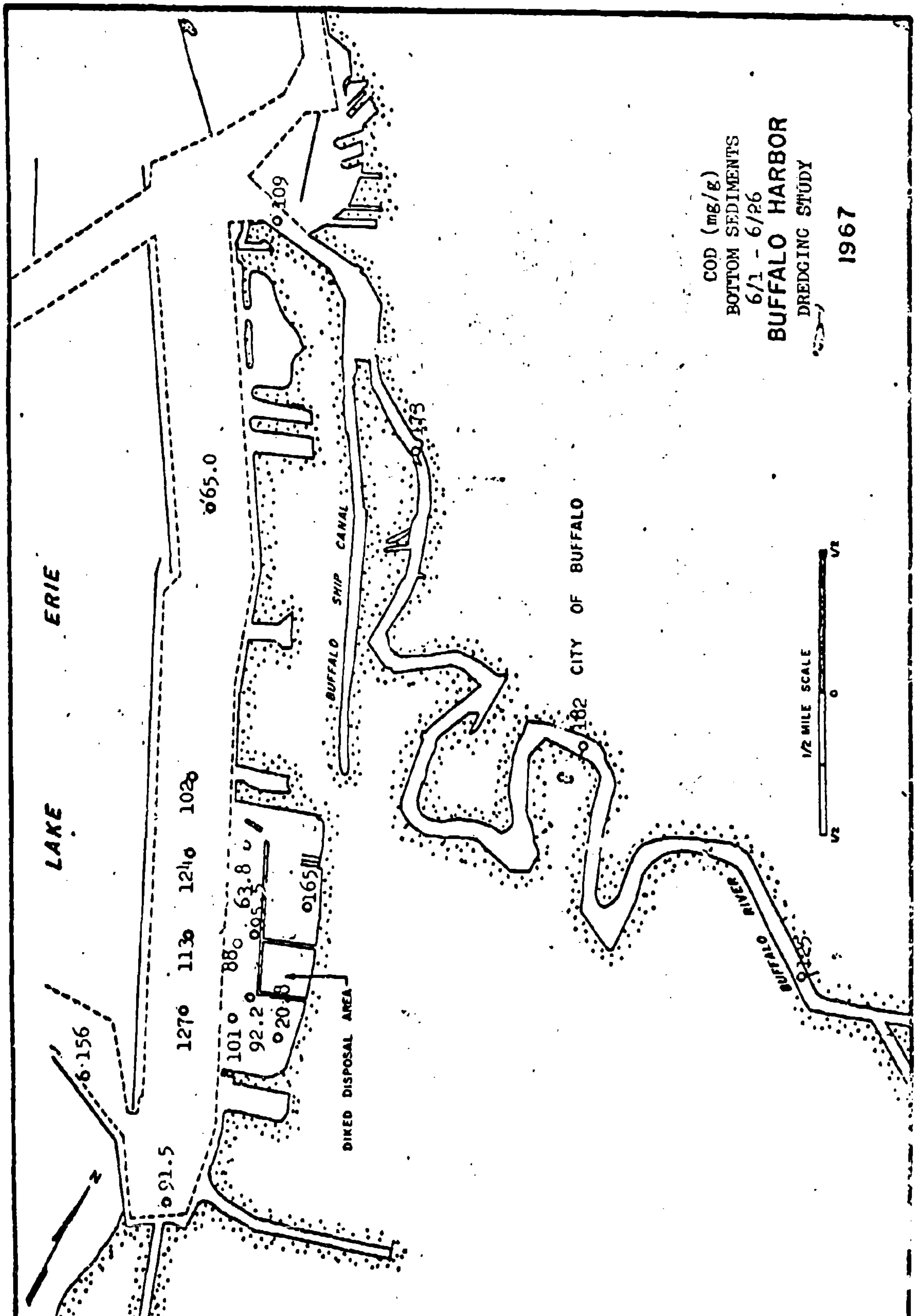

COD (mg/g)
BOTTOM SEDIMENTS
6/1 - 6/26
BUFFALO HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF BUFFALO
BUFFALO SHIP CANAL
BUFFALO RIVER
DIKED DISPOSAL AREA
1/2 MILE SCALE
N
156
91.5
127
113
124
102
65.0
109
173
182
125
101
92.2
20.8
88
63.8
165

Figure 9

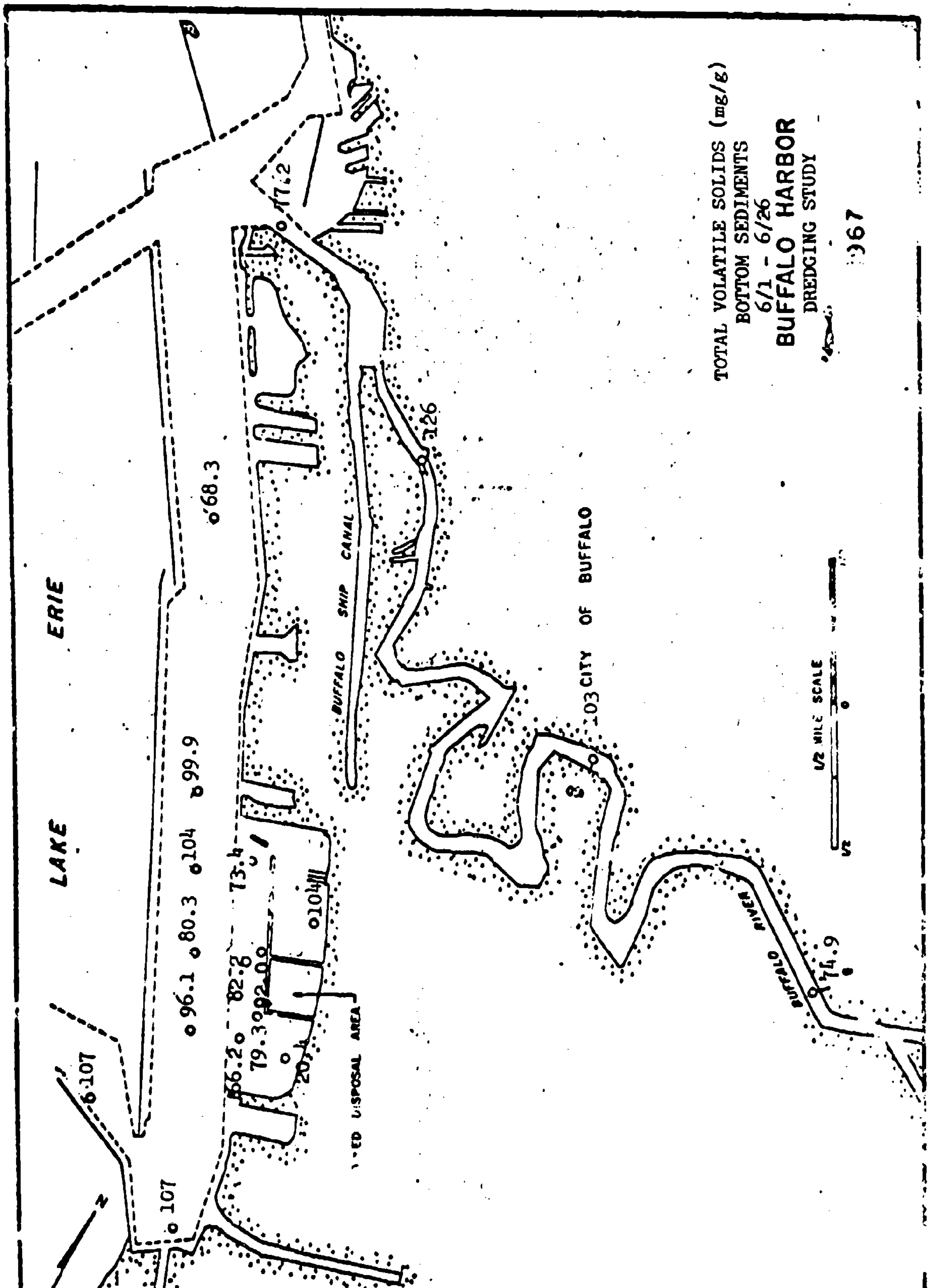

TOTAL VOLATILE SOLIDS (mg/g)
BOTTOM SEDIMENTS
6/1 - 6/26
BUFFALO HARBOR
DREDGING STUDY
LAKE ERIE
BUFFALO SHIP CANAL
CITY OF BUFFALO
BUFFALO RIVER
1/2 MILE SCALE
107
107
96.1
80.3
104
99.9
68.3
126
73.4
104
82.8
79.3
92.0
66.2
74.9
103

Figure 10

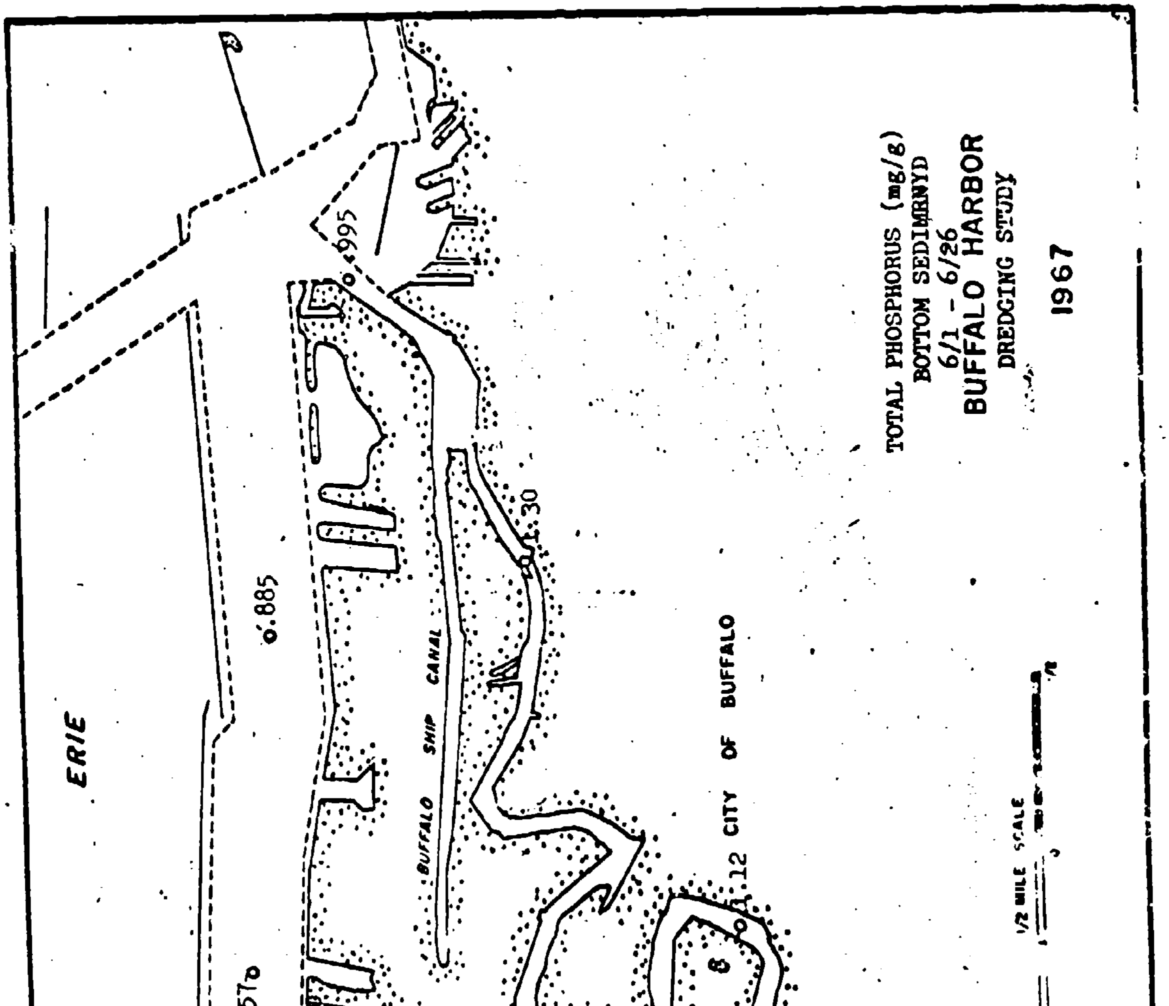

LAKE ERIE
BUFFALO SHIP CANAL
CITY OF BUFFALO
BUFFALO RIVER
DIKED DISPOSAL AREA
N
1/2 MILE SCALE
.330
.943
.992
1.10
.962
.457
.582
1.16
.538
.756
1.02
.920
.867
.885
.995
1.30
1.12
1.17
TOTAL PHOSPHORUS (mg/g)
BOTTOM SEDIMENT
6/1 - 6/26
BUFFALO HARBOR
DREDGING STUDY
1967

Figure 11

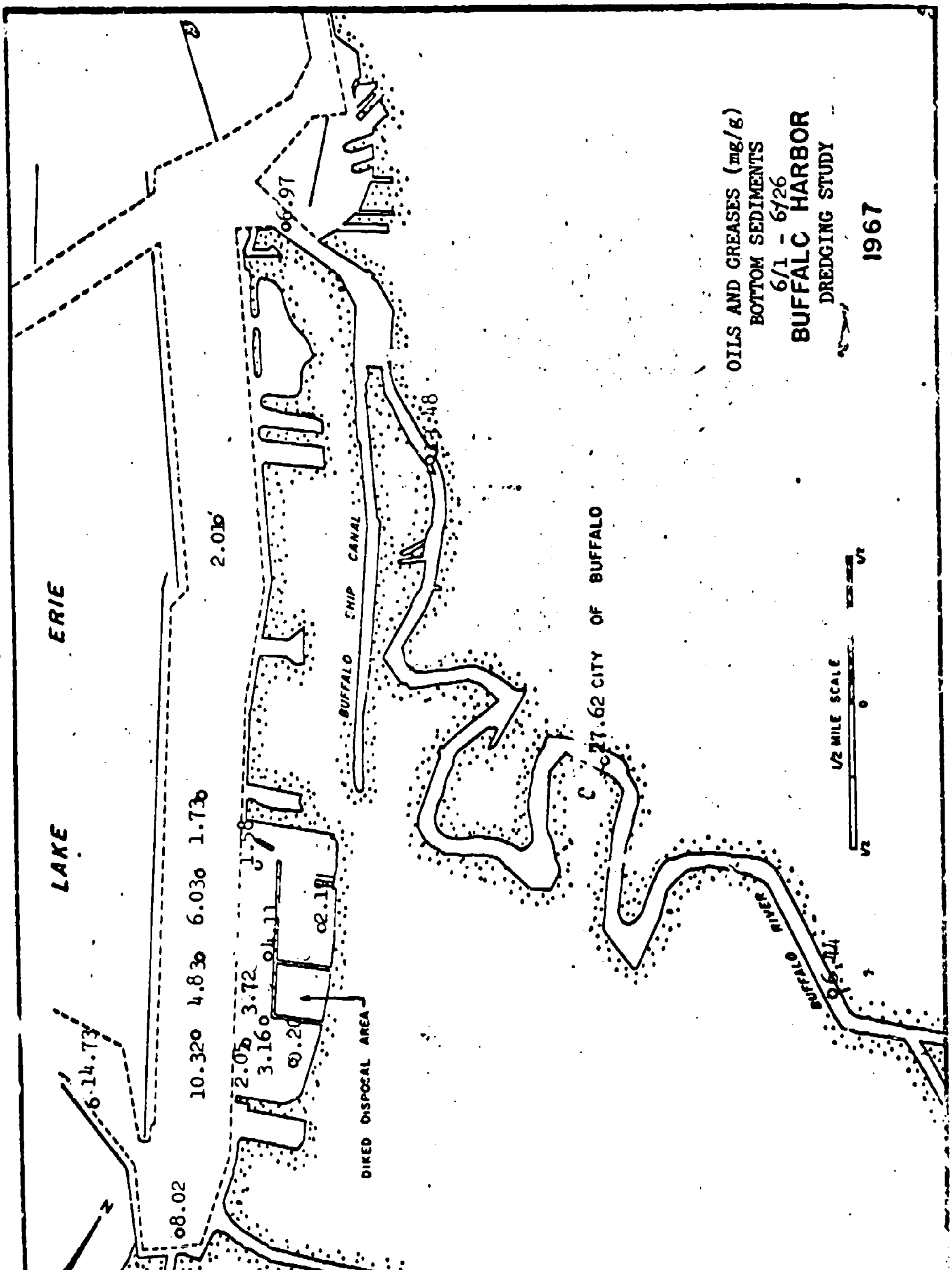

OILS AND GREASES (mg/g)
BOTTOM SEDIMENTS
6/1 - 6/26
BUFFALO HARBOR
DREDGING STUDY
1967
LAKE ERIE
BUFFALO SHIP CANAL
CITY OF BUFFALO
BUFFALO RIVER
DIKED DISPOSAL AREA
1/2 MILE SCALE
6.97
13.48
2.01
27.62
1.73
6.03
4.83
10.32
14.73
8.02
3.72
3.16
4.11
2.18

Figure 12

Donner Hanna plants tends to occur in the harbor and they do not enter the area near the dike.

Sediment Load Summary

The loadings of the various constituents to the Lake Erie dumping grounds resulting from the Buffalo Harbor and Black Rock Channel dredging in 1967 is presented in Table 1. The reported values were calculated from analyses of sediment samples collected from hopper dredge loads and the total dry solids dredged as determined by the Corps of Engineers. Although the number of hopper dredge loads sampled was somewhat limited, the reported values are believed to be reasonably valid.

Table 2 shows the quantity of the constituents of the material dredged from the Buffalo River and placed within the diked area. These values are at best approximate as they are based on the analysis of relatively few samples of in-place sediments collected from the Buffalo River. A larger number of collected samples of the materials loaded on the scows is currently being analyzed. Use of these determinations when available will provide a more dependable estimate. Table 3 shows the average concentration of constituents found in above areas which were used in calculating the loadings.

Benthic Biology

Sludgeworms were the predominant benthic organisms found in most of the areas sampled. The numbers found are presented in Figures 13 and 14. Some areas were essentially devoid of benthic organisms. This was true of the Buffalo River and the extreme south end of the harbor.

TABLE I

LOADINGS TO LAKE ERIE FROM BUFFALO HARBOR
AND BLACK ROCK CHANNEL DREDGING - 1967

Constituent	Harbor (lbs)	Black Rock Channel (lbs)	Total (lbs)
Chemical Oxygen Demand	57,300,000	3,420,000	60,720,000
Chlorine Demand (15 min)	2,230,000	--	--
Volatile Solids	48,900,000	2,530,000	51,430,000
Oil and Grease	3,510,000	184,000	3,694,000
Phosphorus	402,000	28,000	430,000
Nitrogen	1,150,000	62,300	1,212,000
Iron	41,700,000	1,110,000	42,810,000
Total Dry Solids	516,600,000	24,800,000	541,400,000

Note: Based on available data. Additional forthcoming data may result in some adjustment.

TABLE 2

LOADINGS FROM BUFFALO RIVER
DEPOSITED INTO DIKED AREA
1967

Constituent	Pounds
Chemical Oxygen Demand	12,100,000
Volatile Solids	7,810,000
Oul and Grease	1,120,000
Phosphorus	94,400
Nitrogen	215,000
Iron	4,980,000
Total Dry Solids	82,10[illegible],000

Note: Tentative estimate. Forthcoming expected to provide more dependable values.

TABLE I

LOADINGS TO LAKE ERIE FROM BUFFALO HARBOR AND BLACK ROCK CHANNEL DREDGING - 1967

Constituent	Harbor (lbs)	Black Rock Channel (lbs)	Total (lbs)
Chemical Oxygen Demand	57,300,000	3,420,000	60,720,000
Chlorine Demand (15 min)	2,230,000	--	--
Volatile Solids	48,900,000	2,530,000	51,430,000
Oil and Grease	3,510,000	184,000	3,694,000
Phosphorus	402,000	28,000	430,000
Nitrogen	1,150,000	62,300	1,212,000
Iron	41,700,000	1,110,000	42,810,000
Total Dry Solids	516,600,000	24,800,000	541,400,000

Note: Based on available data. Additional forthcoming data may result in some adjustment.

TABLE 2

LOADINGS FROM BUFFALO RIVER
DEPOSITED INTO DIKED AREA
1967

Constituent	Pounds
Chemical Oxygen Demand	12,100,000
Volatile Solids	7,810,000
Oul and Grease	1,120,000
Phosphorus	94,400
Nitrogen	215,000
Iron	4,980,000
Total Dry Solids	82,100,000

Note: Tentative estimate. Forthcoming expected to provide more dependable values.

TABLE 3

AVERAGE CONCENTRATION COMPARISON FOR VARIOUS AREAS
(mg/g dry weight)

Constituent	Vicinity of Dike	Buffalo Harbor	Buffalo River	Black Rock Channel
COD	89	111	147	138
Total Volatile Solids	74.0	94.9	95.2	102
Chlorine Demand (15 min.)	--	4.13	--	--
Oil and Grease	2.43	6.81	13.63	7.43
Total Phosphorus	0.852	0.778	1.15	1.13
Total Nitrogen	1.58	2.23	2.62	2.51
Total Iron	65.5	80.9	60.7	44.8

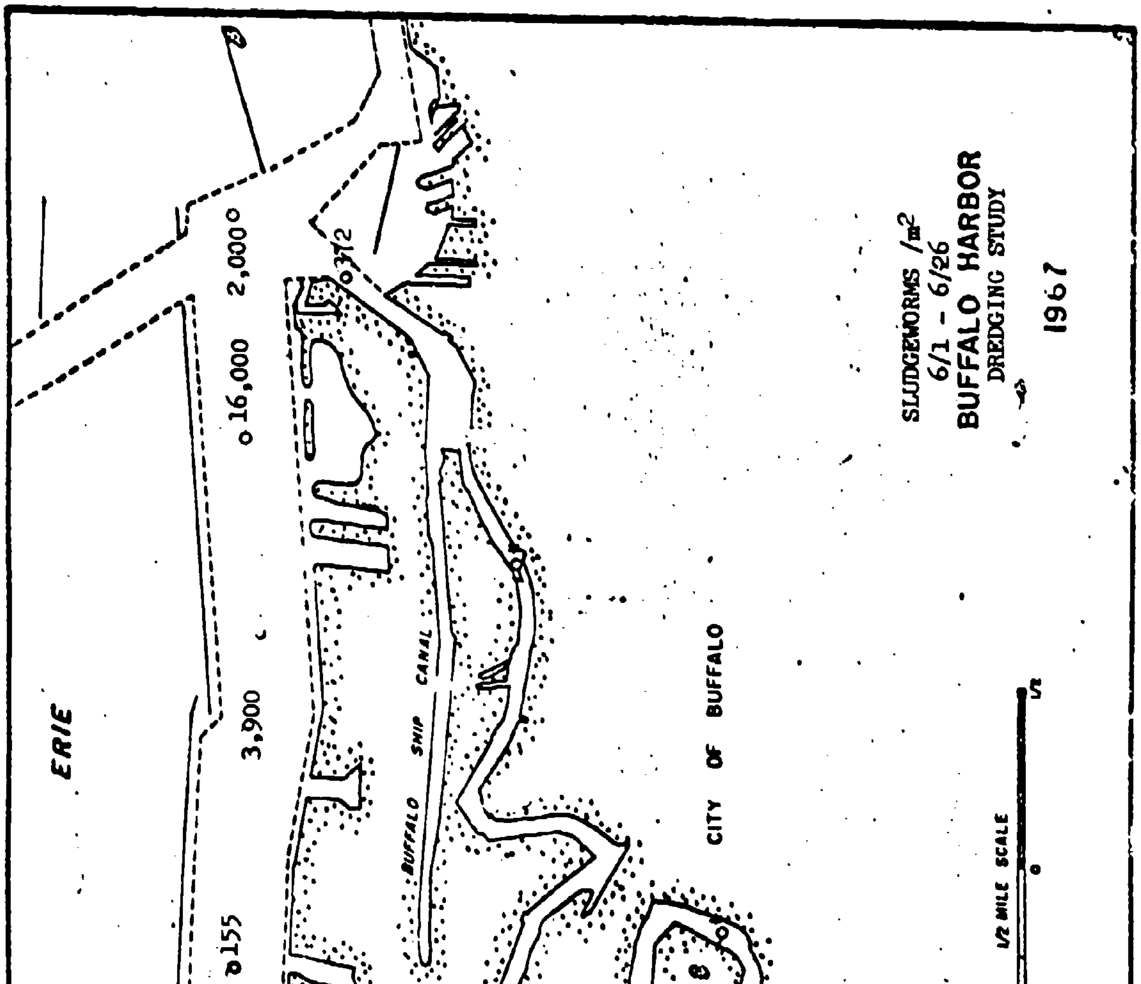

SLUDGEWORMS /m²
6/1 - 6/26
BUFFALO HARBOR
DREDGING STUDY
1967
LAKE ERIE
BUFFALO SHIP CANAL
CITY OF BUFFALO
BUFFALO RIVER
DIKED DISPOSAL AREA
1/2 MILE SCALE
* Essentially devoid of benthic organisms
16,000
2,000
372
3,900
155
6,300
3,300
4,400
4,200
418
46
2,500
4,300
806
6,100
4,600
155
240

Figure 13

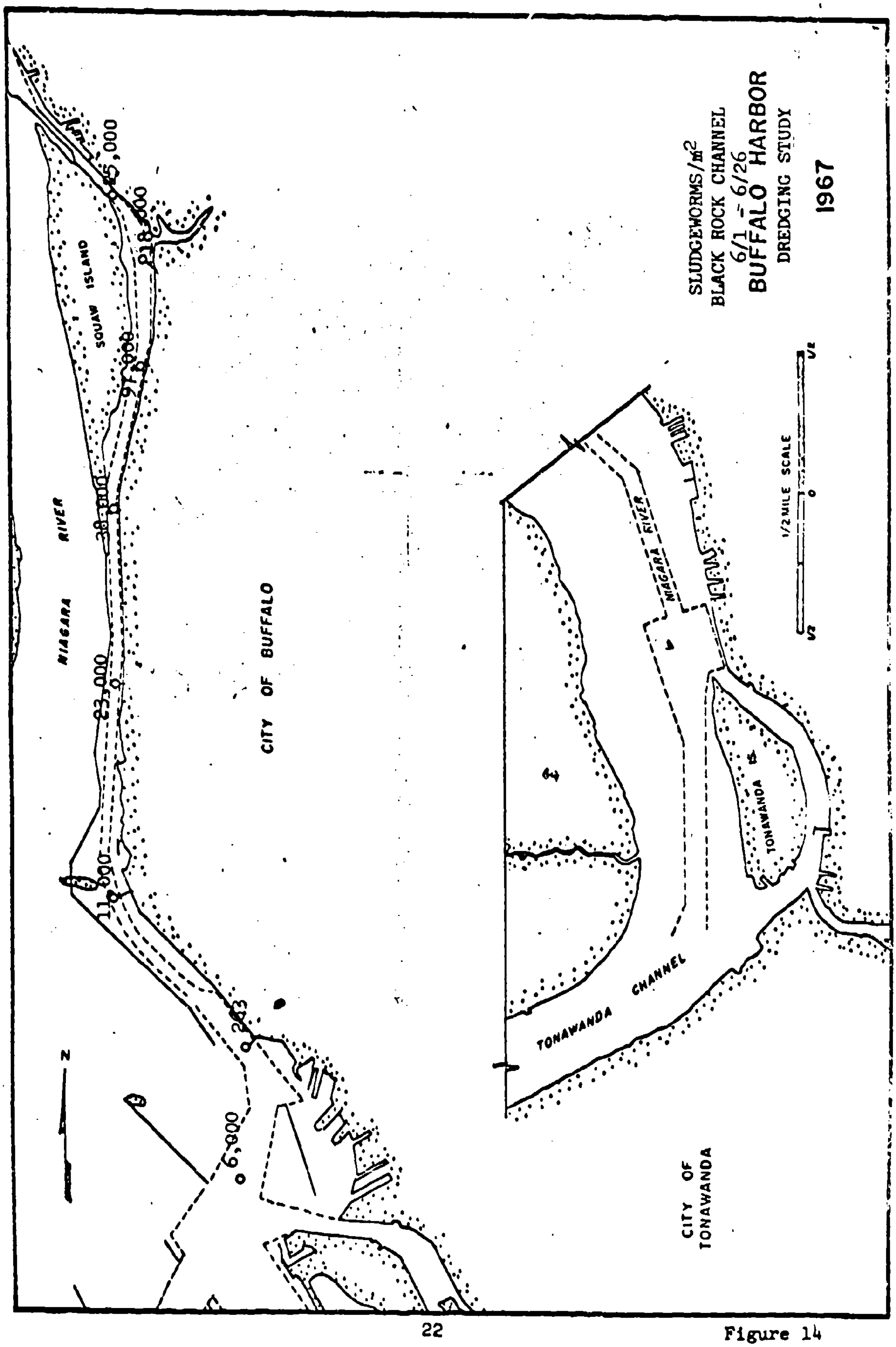

SLUDGEWORMS/m²
BLACK ROCK CHANNEL
6/1 - 6/26
BUFFALO HARBOR
DREDGING STUDY
1967
NIAGARA RIVER
SQUAW ISLAND
CITY OF BUFFALO
CITY OF TONAWANDA
TONAWANDA CHANNEL
TONAWANDA
NIAGARA RIVER
1/2 MILE SCALE
25,000
18,000
91,000
38,800
23,000
11,000
243
6,000
N

Figure 14

Materials toxic to the organisms are suspected of being present in the water and/or sediments at these locations. Smothering by erosion materials may also play a part.

In the Black Rock Channel sludgeworms were overwhelmingly dominant. In the portion of the harbor extending from the dike area to the north end of the harbor there were fewer sludgeworms and a somewhat more balanced benthic population. This indicates that this sector is somewhat less polluted which was also shown by the chemical characteristics of the sediments.

Samples for determination of benthic organisms present in the area surrounding the dike area were also collected after termination of the 1967 dredging. Similar determinations are to be made prior to 1968 dredging operations. A comparative evaluation of the organisms present before and after dredging may provide significant information as to the effect of dredging operations.

WATER ANALYSIS

The ranges of the concentrations of constituents present in the waters in river, harbor, channel, and dike disposal areas prior to dredging operations are shown in Table 4. The waters at the lake dumping were not investigated as the available time was limited. It was believed that the high background concentrations due to Bethlehem Steel waste discharges in the immediate area would obscure any before and after changes in water quality and render such investigation relatively inconclusive.

The disposal of dredgings from the Buffalo River was somewhat

TABLE 4

CONCENTRATION RANGES OF WATER CONSTITUENTS

Constituent	Vicinity of Dike	Buffalo Harbor	Buffalo River	Black Rock Channel
Total Phosphorus	0.03-0.08	0.03-0.06	0.17-0.82	0.04-0.08
Organic N mg/l	0.28-0.70	0.39-1.01	2.02-4.93	0.39-0.68
Ammonia N mg/l	0.01-0.14	0.01-0.10	0.05-0.10	0.03-0.22
Nitrate N mg/l	0.06-0.13	0.02-0.10	0.14-0.32	0.06-0.23
Chloride mg/l	23-26	23-26	38-64	24-35
Phenol µg/l	0-3	0-20	32-1590	0
Total Solids mg/l	176-375	206-273	207-428	231-345
Suspended Solids mg/l	0-8	0-8	0-50	2-32
Conductivity micromhos/cm	320-340	320-350	400-670	320-400
Coliforms/100 ml	70-400	100-800	15,000-36,000	<10-4600

TABLE 5

MEDIAN COLIFORM CONCENTRATIONS
(org/100 ml)

	Vicinity of Dike	Buffalo Harbor	Buffalo River	Black Rock Channel
Coliforms/100 ml	350	400	21,000	1,920

curtailed and not completed until the end of November. This limited the extent of sampling during and after the dredging. Not all of the analyses of these samples have been completed. Preliminary examination of the currently available data does not indicate any changes in the water quality outside of the diked area due to disposal operations. It should be recognized that the analytical methods for parameters used may not be sufficiently sensitive to show slight changes that do occur in the surrounding waters. Table 5 shows median coliform concentrations in the areas studied. No changes in the bacterial quality of the water outside the diked area due to disposal operations are discernable.

CONSTITUENTS IN THE INFLOW AND OUTFLOW OF HOPPER DREDGES

Data on certain constituents in the inflow and outflow of hopper dredges are presented in Table 6. The values shown are the average concentrations of those found in several dredge loads.

SOME TENTATIVE CONCLUSIONS

The hopper dredging operations in the Buffalo Harbor and the Black Rock Channel markedly increased the visually observed turbidity and floating oils in the area dredged during the operations. The oil films persisted for some time after the dredging.

From limited data now available, it appears that the disposal of dredged materials within the diked area does not create any significant detrimental effect on the waters surrounding the dike.

It is believed that the more accurate procedure for determining the constituent loadings in the dredged materials is to collect

TABLE 6

AVERAGE CONCENTRATION OF CONSTITUENTS IN INFLOW AND OUTFLOW OF HOPPER DREDGES
mg/l

Constituent	Buffalo Harbor Inflow 6-15-67	Buffalo Harbor Outflow 6-15-67	Buffalo Harbor Inflow 6-19-67	Buffalo Harbor Outflow 6-19-67	Black Rock Channel Inflow 7-5-67	Black Rock Channel Outflow 7-5-67
COD	33,200	16,000	22,300	14,600	47,000	35,000
Chlorine Demand	--	--	1,350	682	--	--
Oil and Grease	107	302	176	231	790	181
Total Phosphorus	12.2	5.02	9.23	9.00	29.4	18.2
Total Nitrogen	433	341	396	375	1,004	696
Total Iron	2,141	1,361	1,435	908	2,020	1,158
Hydrometer Density	1.196	1.125	1.180	1.098	1.150	1.063
Total Volatile Solids	24,400	17,900	21,000	13,700	40,000	20,600
Total Solids	353,000	213,000	296,000	165,000	336,000	147,000

representative samples of the materials loaded on the dredges or scows. Sampling of hopper dredge inflow and overflow does present some problems.

APPENDIX A 4

INTERIM SUMMARY OF CLEVELAND

HARBOR DREDGING EFFECTS INVESTIGATION

1 9 6 7

By
Robert P. Hartley
Chief, Surveillance Section

December 1967

CLEVELAND PROGRAM OFFICE

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

Revised September 1968

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INTERIM SUMMARY OF CLEVELAND
HARBOR DREDGING EFFECTS INVESTIGATION
DECEMBER 1967
CLEVELAND PROGRAM OFFICE

INTRODUCTION

This summary of the Cleveland Harbor dredging investigation only includes data on sampled in-place materials (sediment and water) from the harbor and dumping area. It is essentially a preliminary report on effects pertaining to present methods of dredging and disposal, even though the actual operational characteristics of dredging have not yet been investigated in detail.

The final report on dredging for the Cleveland area will include detail on the water quality effects of various disposal methods (i.e. deep water versus diked area), the immediate effects of the dredging operation (material removed versus material returned), and specific criteria for determining the disposal and dredging methods. To complete the investigation several analyses remain to be made. The Cleveland diked area (pilot dike) will be studied intensively as will the dredged materials while dredging.

In addition to the Cleveland investigation all other Lake Erie harbors will be sampled to determine the quality of existing sediments in more detail. This is necessary in order to make a sensible judgment on disposal methods. It is recognized that it may not be wise to keep all harbor sediments from reaching the lake and that some may be beneficial. These investigations will be reported separately from the Cleveland report.

The summary is based upon sampling of bottom sediments and overlying water in the Cuyahoga River navigation channel, the outer Cleveland Harbor, and the dredging dump for these areas. Figure 1 shows the sampling locations. The characteristics of central Lake Erie bottom sediments are based upon sampling done in 1963.

The schedule of sampling at Cleveland is shown in Table 1. The sampling was designed around dredging schedules. The river was dredged by clamshell between 28 March and 1 July 1967 and the outer harbor was hopper dredged between 27 March and 6 April 1967.

Tabulations of analyses are not presented in this report but are available at the Cleveland Program Office, FWPCA.

SEDIMENT ANALYSIS

Figures 2 through 7 show the results of several sediment analyses as value profiles for the river, the harbor, and the dump.

Chlorine Demand

Chlorine demand (15 minute) was determined on a dry weight basis for bottom sediments at the river and harbor stations in September 1967. It has not been determined for any dump or lake bottom samples.

Cuyahoga River sediments have a high chlorine demand (Figure 2), due probably to high ferrous iron content. Test results were erratic as might be expected but above one mile from the river mouth the demand averaged more than 30 mg/g. Using data provided by the Corps of Engineers on sediment density(1200 lbs dry wt/yd^3), the average 15 minute demand per cubic yard of in-place sediment would be approximately 36 pounds. Extending this to an average scow load of dredged material (1350 cubic yards) the demand would be 48,600 pounds. Extending further

TABLE 1

CLEVELAND HARBOR DREDGING STUDY SAMPLING

Sampling Location	3/23	3/24	3/27	3/28	3/29	3/30	3/31	4/3	4/4	4/10	4/12	4/17	6/12	6/13	6/14	6/16	6/21	6/22	7/10	7/11	7/12	7/13	7/17	7/18	9/12	9/14	9/15	9/18	9/20	9/21	9/22	9/25	9/26	9/27	9/29	10/2	10/3	10/4
River																																						
C22-2		1					3			4			5								6				7				7									
CR0.3		1					3			4			5								6				7				7									
CR0.8		1											5							6					7				7									
CR1.3			1										5							6					7					7								
CR1.6			1										5							6					7					7								
CR2.3			1											5						6					7					7								
CR2.9			1											5						6					7					7								
CR3.5			1											5					6						7					7								
CR4.2			1											5					6						7						7							
CR4.5				2										5					6						7						7							
CR4.9				2										5					6						7						7							
CR5.4				2															6						7						7							
Old CR0.3		1											5								6				7				7									
Old CR0.9		1											5								6				7				7									
Harbor																																						
C22-1		1					3			4																						7						
C22-4	1						3			4																								7				
C22-6		1					3			4																						7						
C22-7		1				3	3			4																								7				
C22-8	1						3			4																							7					
C22-11	1						3			4																								7				
C22-13	1						3			4																								7				
C22-24	1						3			4																									7			
C22-26	1						3			4																												7
C22-27		1					3			4																						7						
C23-1				2			3			4																											7	
C23-3				2			3			4																											7	
C23-4							3			4																												7
Dump																																						
C22-5			1					3			4				5						6											7						
C22-9					2			3			4				5							6											7					
C22-10			1			3		3			4				5							6						7										
C22-12						3		3			4				5							6				7												
C22-14					2			3			4					5							6				7											
C22-15					2			3			4					5							6				7											
C22-16					2			3			4					5							6										7					
C22-17					2			3			4					5							6				7											
C22-18						3		3			4						5						6			7												

TABLE 1 (Cont.)

CLEVELAND HARBOR DREDGING STUDY SAMPLING

Sampling Location	Sampling Data																																				
	3/23	3/24	3/27	3/28	3/29	3/30	3/31	4/3	4/4	4/10	4/12	4/17	6/12	6/13	6/14	6/16	6/21	6/22	7/10	7/11	7/12	7/13	7/17	7/18	9/12	9/14	9/15	9/18	9/20	9/21	9/22	9/25	9/26	9/27	9/29	10/2	10/3	10/4
Dump(cont.)																																						
C22-19						3		3			4					5							6													7		
C22-20						2			3			4					5							6												7		
C22-21						2			3			4					5							6												7		
C22-22						3			3			4					5							6												7		
C22-23						3			3		4	4					5							6												7		
C22-25						3			3			4						5						6													7	
C23-5						3			3			4						5						6													7	

1. Before any dredging
2. During hopper and scow dredging - before scow dumping
3. During hopper and scow dredging - after scow dumping
4. During scow dredging - after hopper dredging
5. During scow dredging - long after hopper dredging
6. After all dredging
7. Long after all dredging

Hopper dredging outer harbor 3/27-4/6/67
Clamshell dredging river 3/28-7/1/67

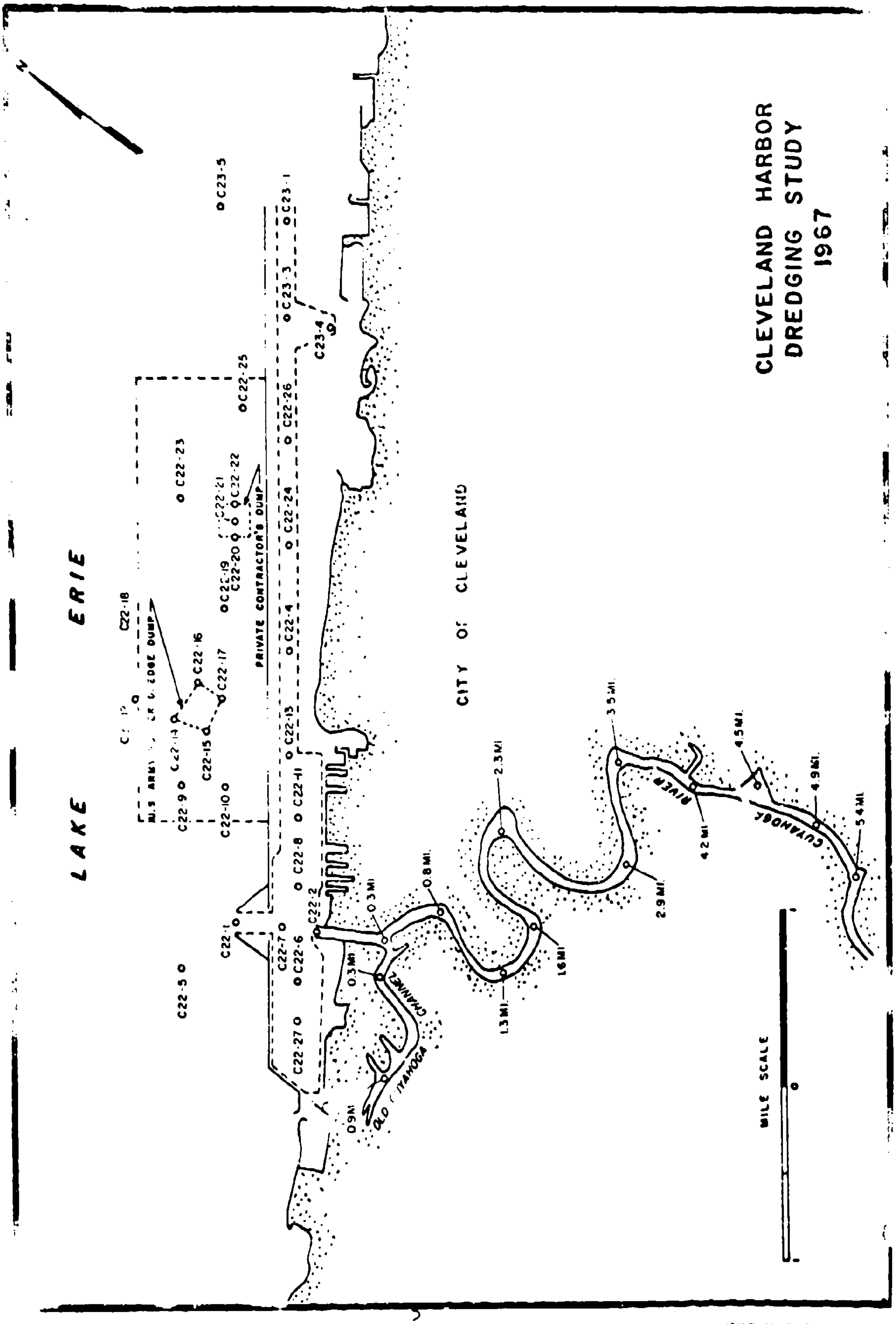
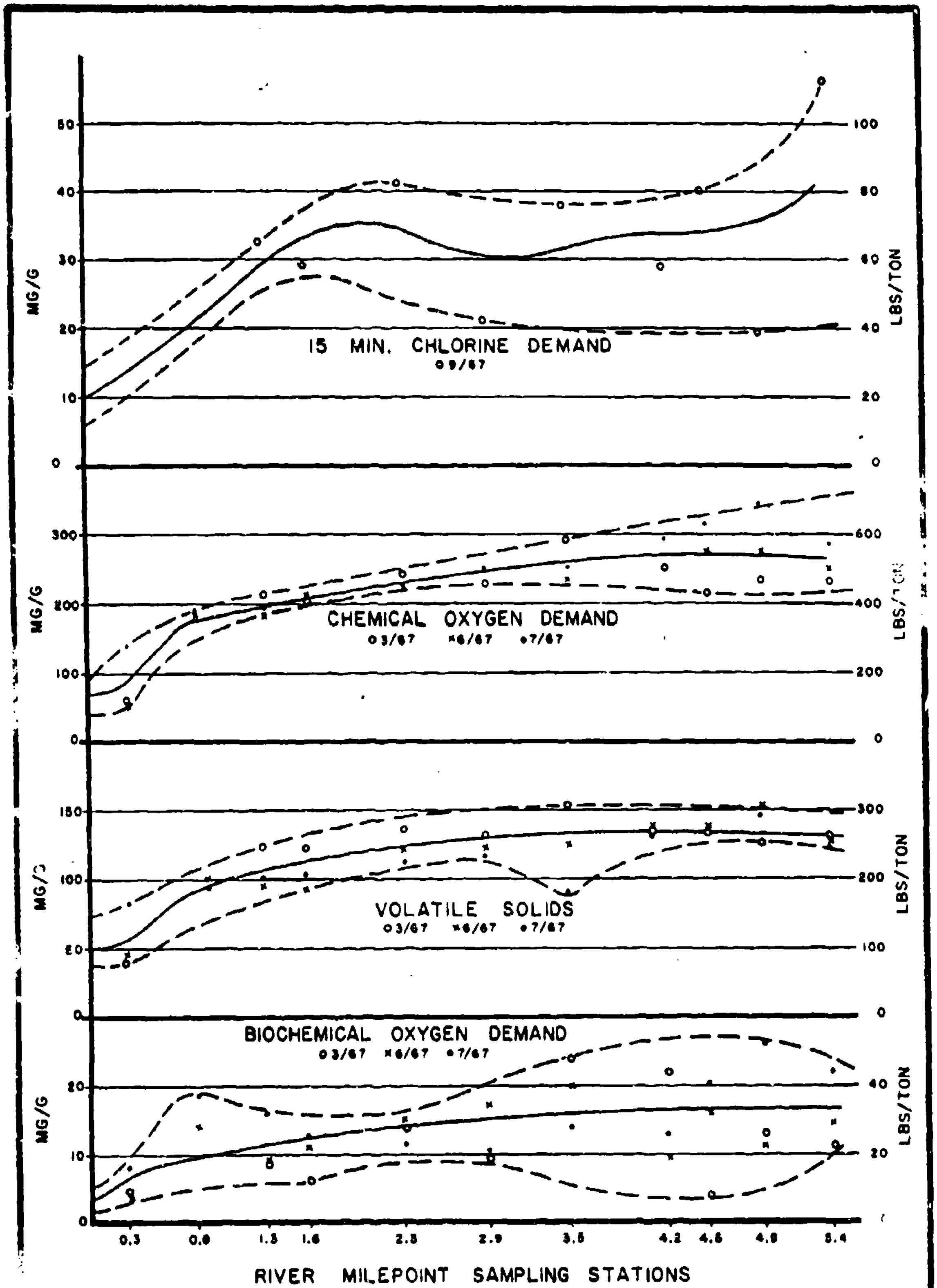
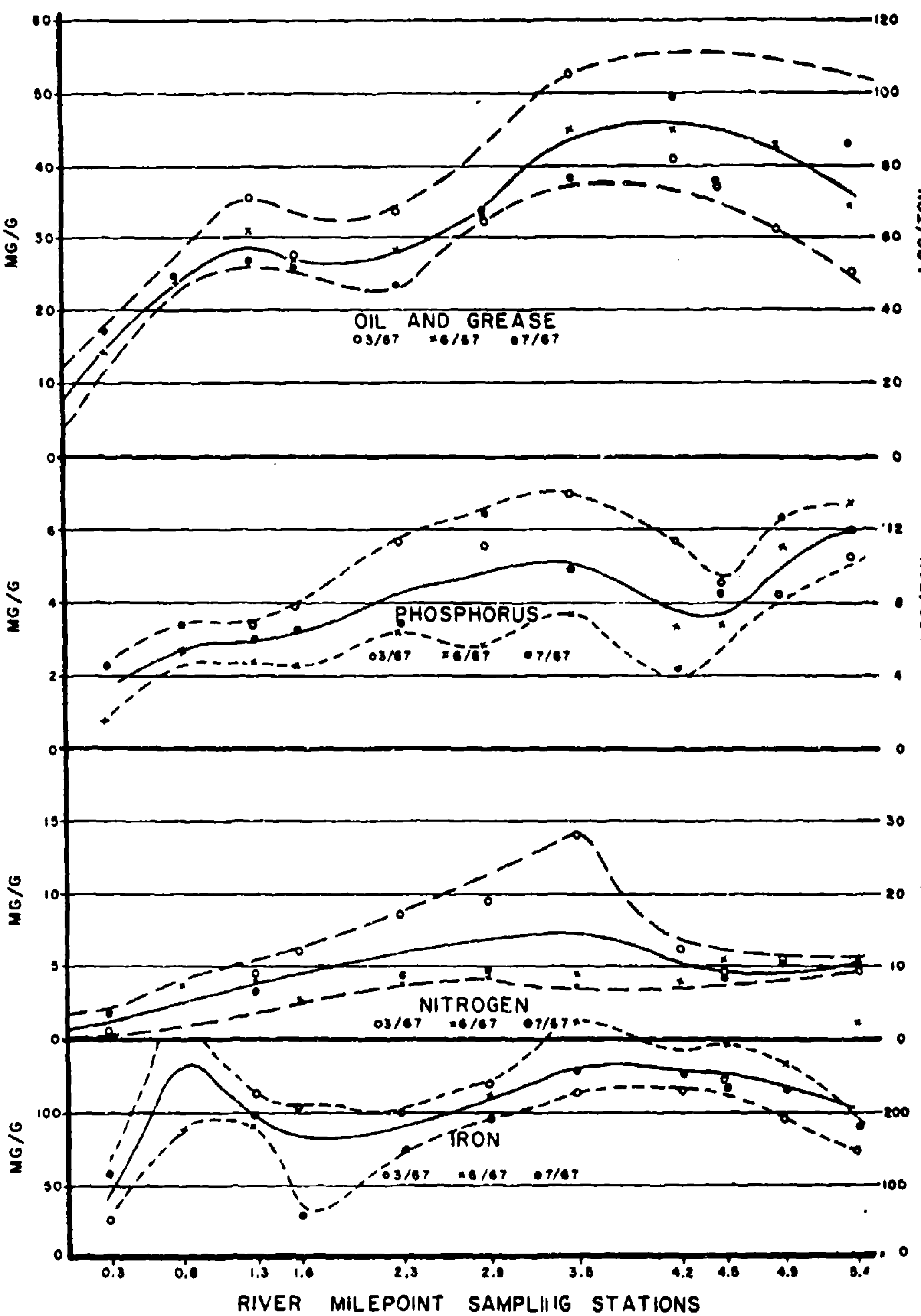

CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY CORPS OF ENGINEERS DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
OLD CUYAHOGA CHANNEL
MILE SCALE
0
1
C22-1
C22-2
C22-5
C22-6
C22-7
C22-8
C22-9
C22-10
C22-11
C22-14
C22-15
C22-16
C22-17
C22-18
C22-19
C22-20
C22-21
C22-22
C22-23
C22-24
C22-25
C22-26
C22-27
C22-4
C22-13
C23-1
C23-3
C23-4
C23-5
0.3 MI
0.8 MI
0.9 MI
1.3 MI
1.6 MI
2.3 MI
2.9 MI
3.5 MI
4.2 MI
4.5 MI
4.9 MI
5.4 MI

FIGURE 1



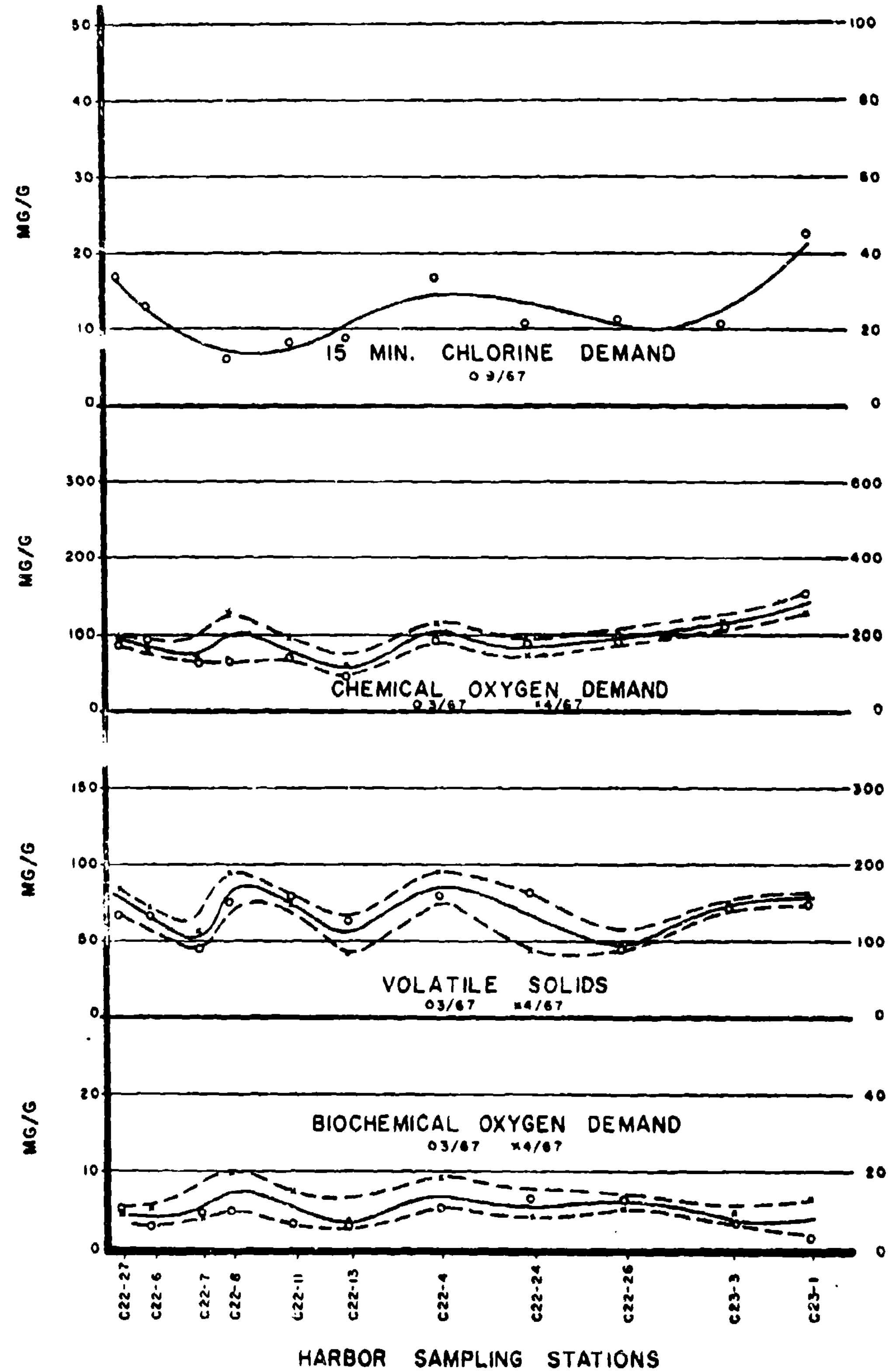
CUYAHOGA RIVER SEDIMENT DATA

FIGURE 2



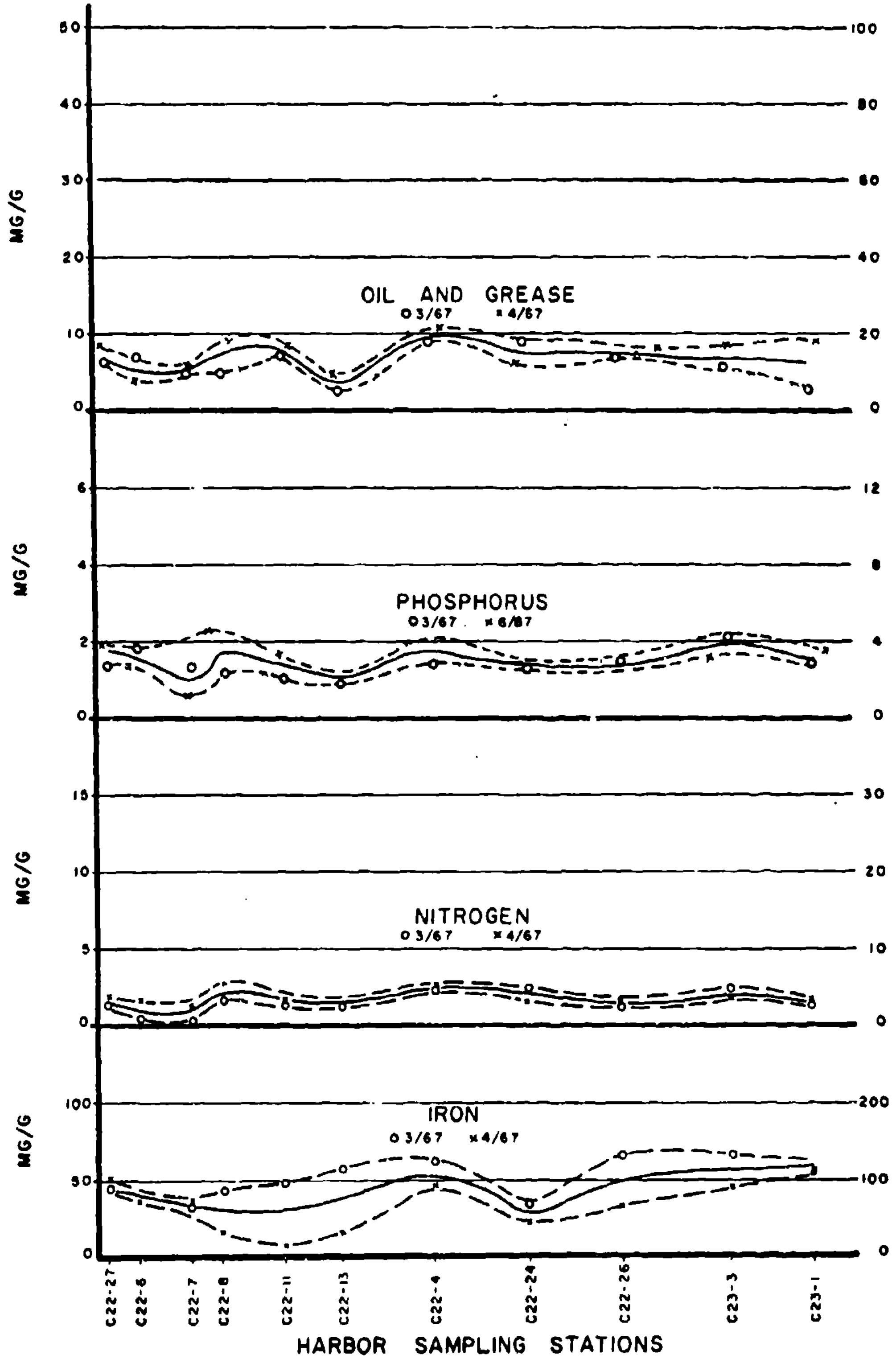
CUYAHOGA RIVER SEDIMENT DATA

FIGURE 3



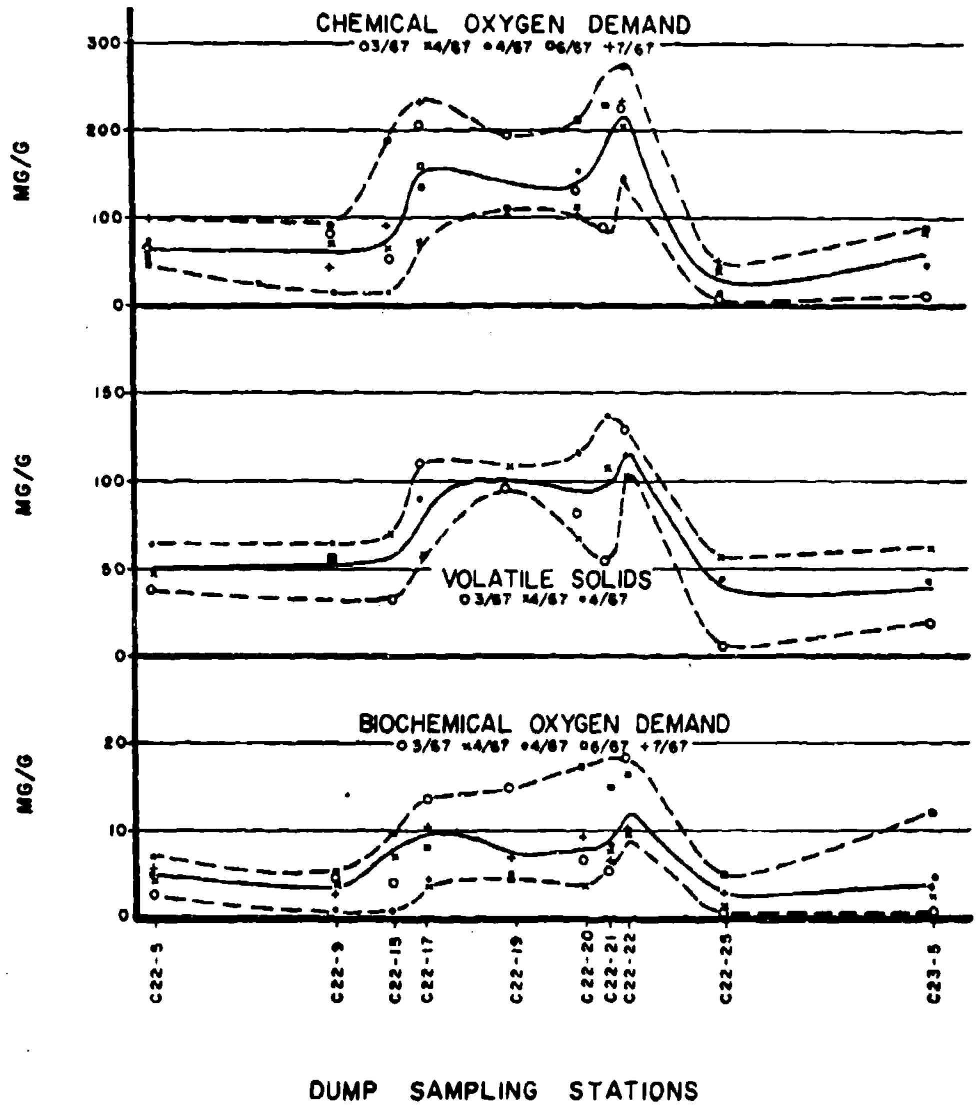
CLEVELAND HARBOR SEDIMENT DATA

FIGURE 4



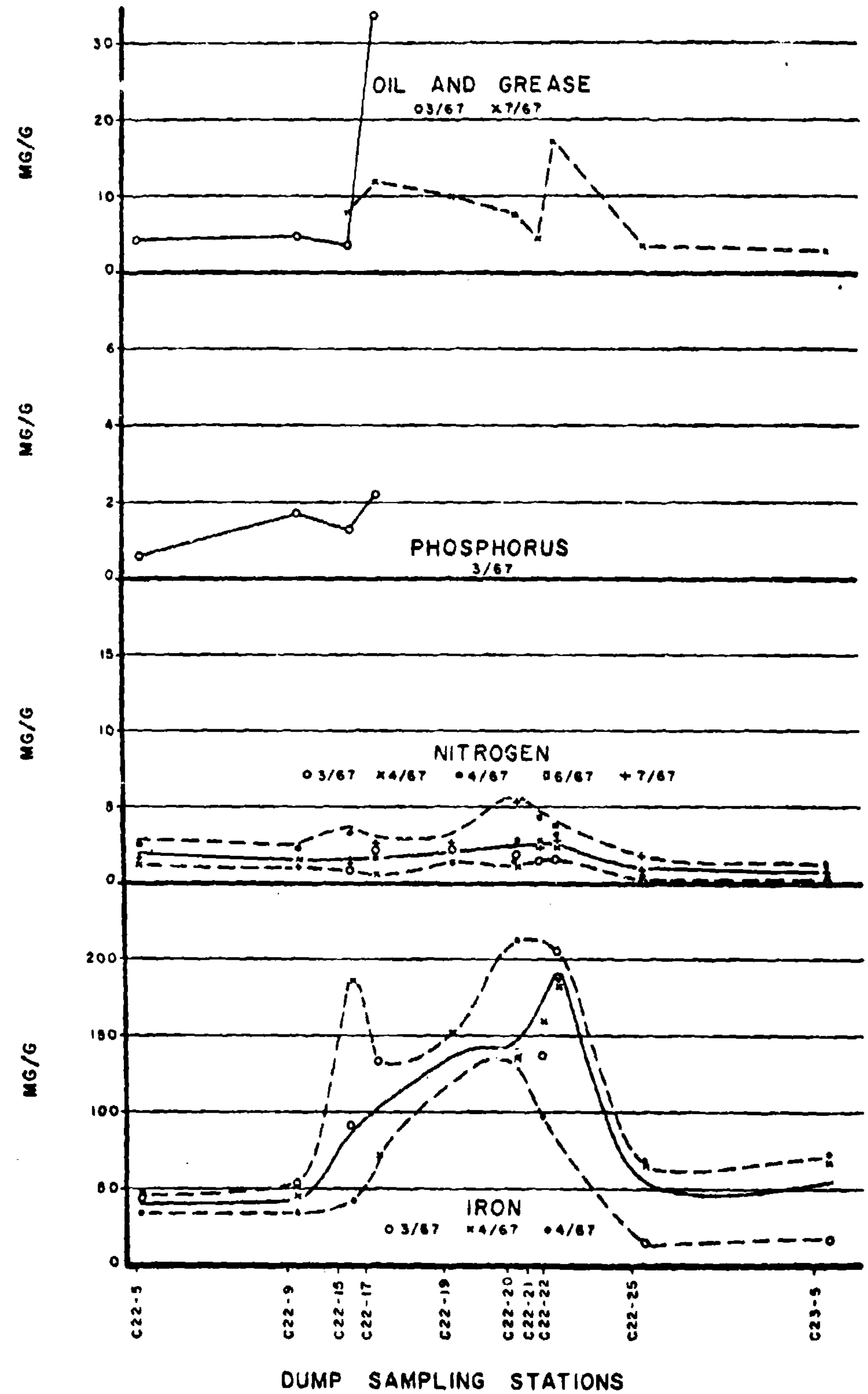
CLEVELAND HARBOR SEDIMENT DATA

FIGURE 5



CLEVELAND DUMPING GROUND SEDIMENT DATA

FIGURE 6



CLEVELAND DUMPING GROUND SEDIMENT DATA

FIGURE 7

to the yardage removed from the Cuyahoga during the past year (773,000 cubic yards), 28 million pounds of chlorine would probably have been required to satisfy the 15-minute demand.

In the lower one mile of the Cuyahoga River the chlorine demand decreased rapidly to the level of the outer harbor.

Chlorine demand in the outer Cleveland Harbor, that part of the harbor between shore and the offshore breakwater, averaged about 12 mg/g or 24 lbs/ton dry weight. Extending this to a hopper dredge load equivalent of 850 tons dry solids, the demand is 20,000 pounds per load. Extending again to the amount of sediment removed in the past year, (199,000 tons) the total 15-minute demand would have been 4,776,000 pounds.

The chlorine demand per unit of dry weight in the outer harbor sediments is only about half of that in the river sediments.

Chemical Oxygen Demand

The chemical oxygen demand (COD) of the river sediments is high (Figure 2). This demand climbs steeply in the lower one mile of the river from an average of 70 mg/g to 170 mg/g. Above one mile the average climbs gradually to about 270 mg/g near the head of the navigation channel. A maximum of 341 mg/g was recorded about five miles upstream. An average for the entire river would be about 240 mg/g or about 480 lbs/ton dry weight. This is roughly equivalent to 290 lbs/yd^3 of in-place sediment or 391,500 pounds per scow load of 1350 cubic yards. Extending this to the total past year's river dredging, 223,570,000 pounds of COD was removed.

The chemical oxygen demand of the outer harbor sediments averaged about 95 mg/g or 190 lbs/ton dry weight or less than 40 percent of that in the river. Using 850 tons as a hopper dredge load, 161,000 pounds of COD would be contained therein. For the past year's hopper dredging 37,810,000 pounds of COD was removed. This is only about one-sixth of that dredged from the river.

Chemical oxygen demand of the sediments in the dumping ground varied widely with time indicating either considerable transport or change of in-place sediment character. Both phenomena are probably responsible. Figure 8, 9, 10 and 11 indicate the magnitude of the changes. Figure 6 shows a longitudinal COD profile in the dumping ground. The two areas of dumping are prominent with the river dumping site showing highest values. The background sediment COD in this area was apparently in the vicinity of 80 mg/g.

Volatile Solids

Volatile solids in the Cuyahoga River followed a pattern similar to COD with a rapid increase upstream in the lower mile from about 50 to about 100 mg/g dry weight (Figure 2). Above one mile the increase was gradual to about 135 mg/g in the upper two miles of the navigation channel. The average for the river was about 125 mg/g or 250 lbs/ton. This is equivalent to approximately 150 pounds per cubic yard of in-place sediment or 202,500 pounds per dredging scow load. This ratio applied to the past year's dredging gives 116,433,000 pounds of volatile solids taken from the river.

Volatile solids in the outer harbor also followed a pattern similar to COD (Figure 4). The average concentration was about 65 mg/g - 130 lbs/ton - slightly less than half the concentration in the river.

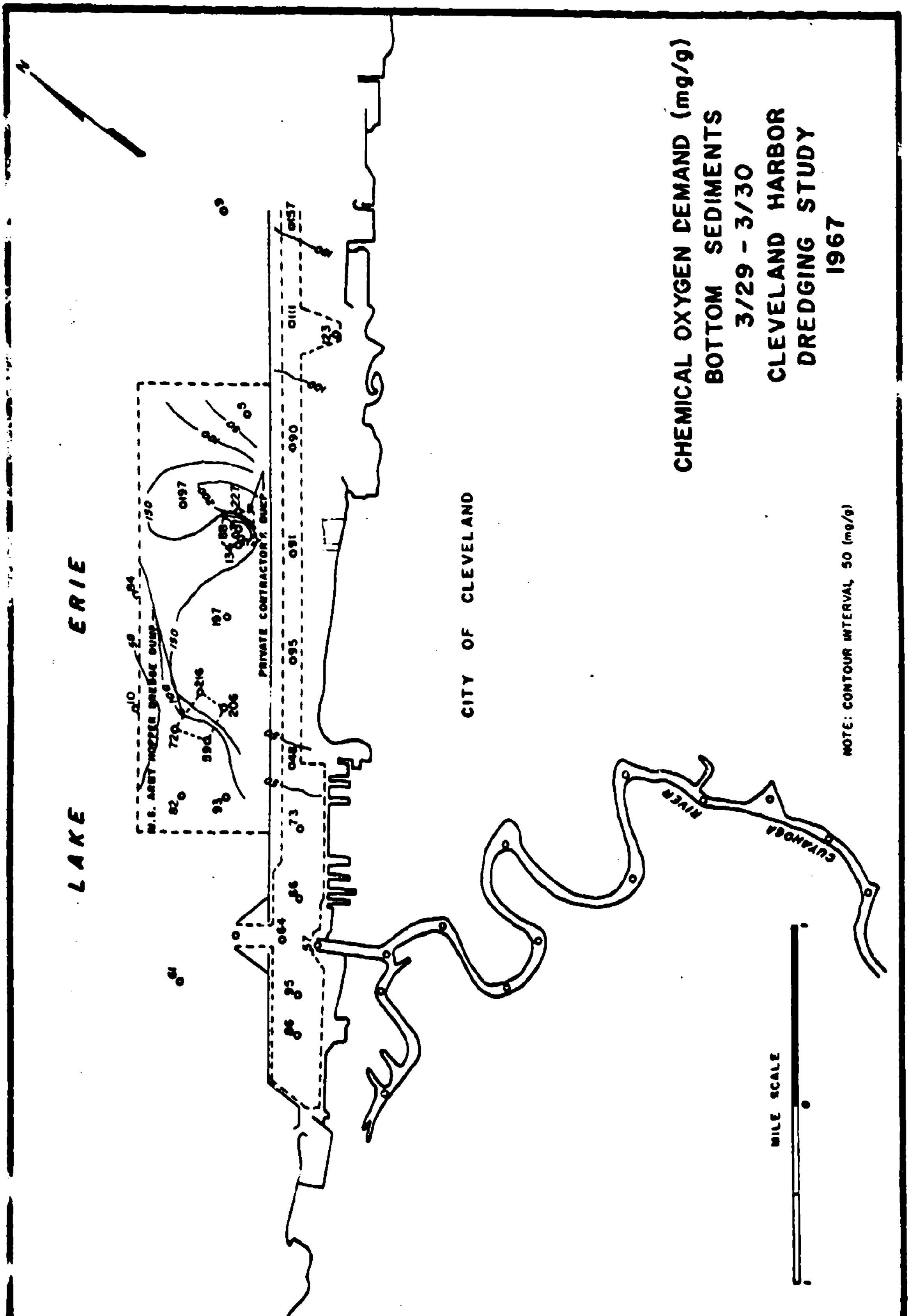

CHEMICAL OXYGEN DEMAND (mg/g)
BOTTOM SEDIMENTS
3/29 - 3/30
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
CUYAHOGA RIVER
PRIVATE CONTRACTOR'S DUMP
NOTE: CONTOUR INTERVAL 50 (mg/g)
MILE SCALE

FIGURE 8

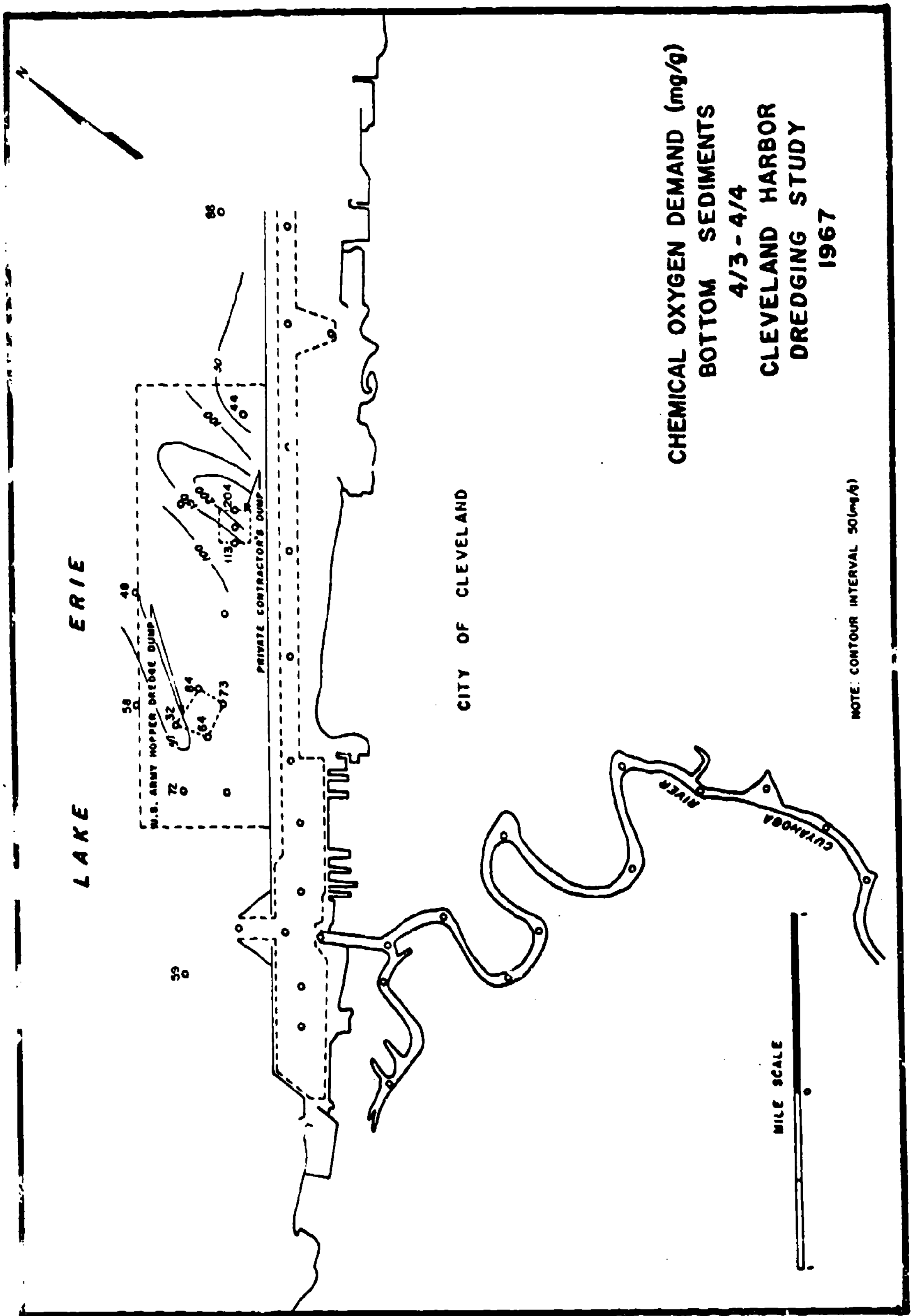
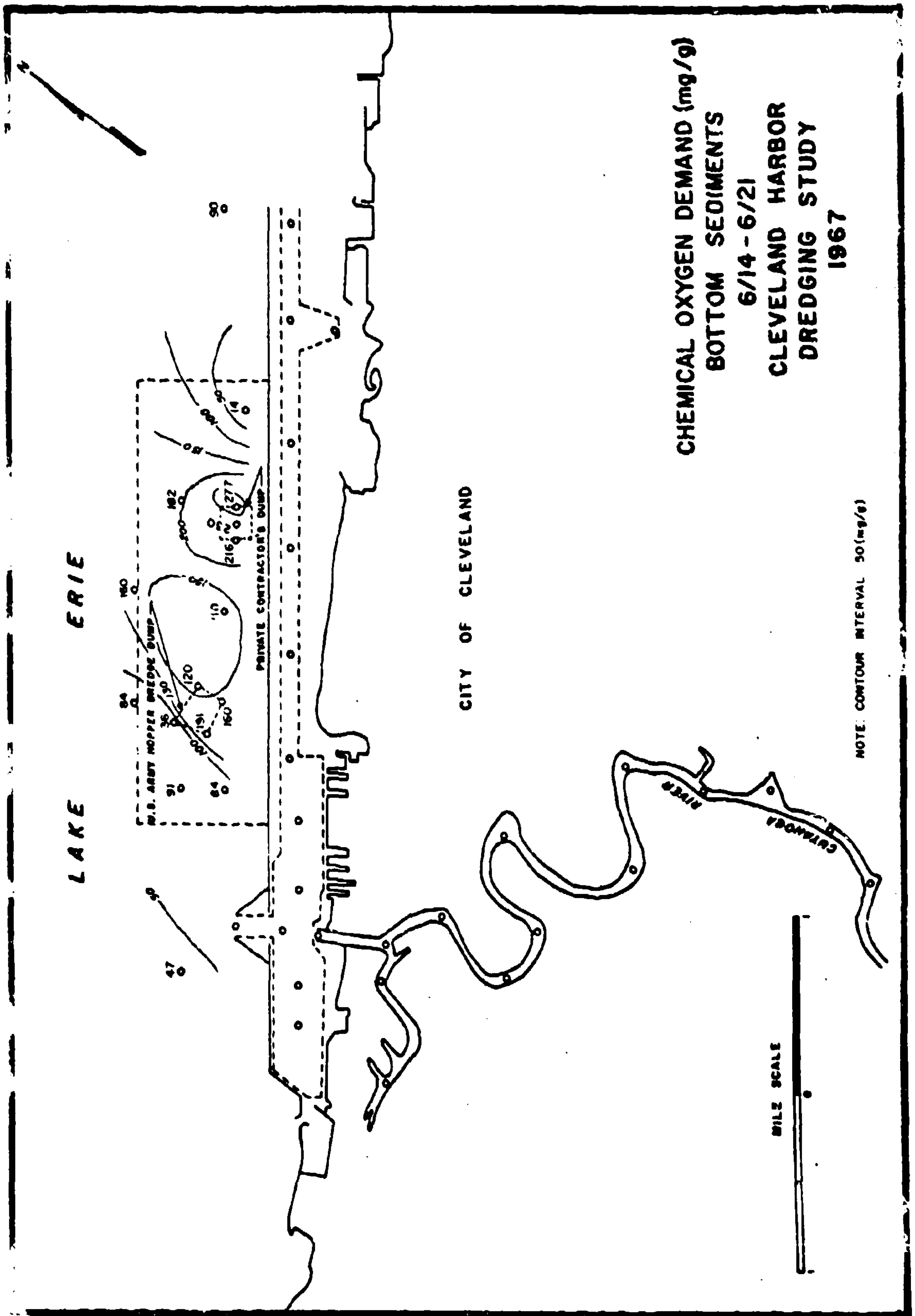

CHEMICAL OXYGEN DEMAND (mg/g)
BOTTOM SEDIMENTS
4/3 - 4/4
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
MILE SCALE
NOTE: CONTOUR INTERVAL 50(mg/g)

FIGURE 9



CHEMICAL OXYGEN DEMAND (mg/g)
BOTTOM SEDIMENTS
6/14 - 6/21
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
MILE SCALE
NOTE: CONTOUR INTERVAL 30 (mg/g)
N

FIGURE 10

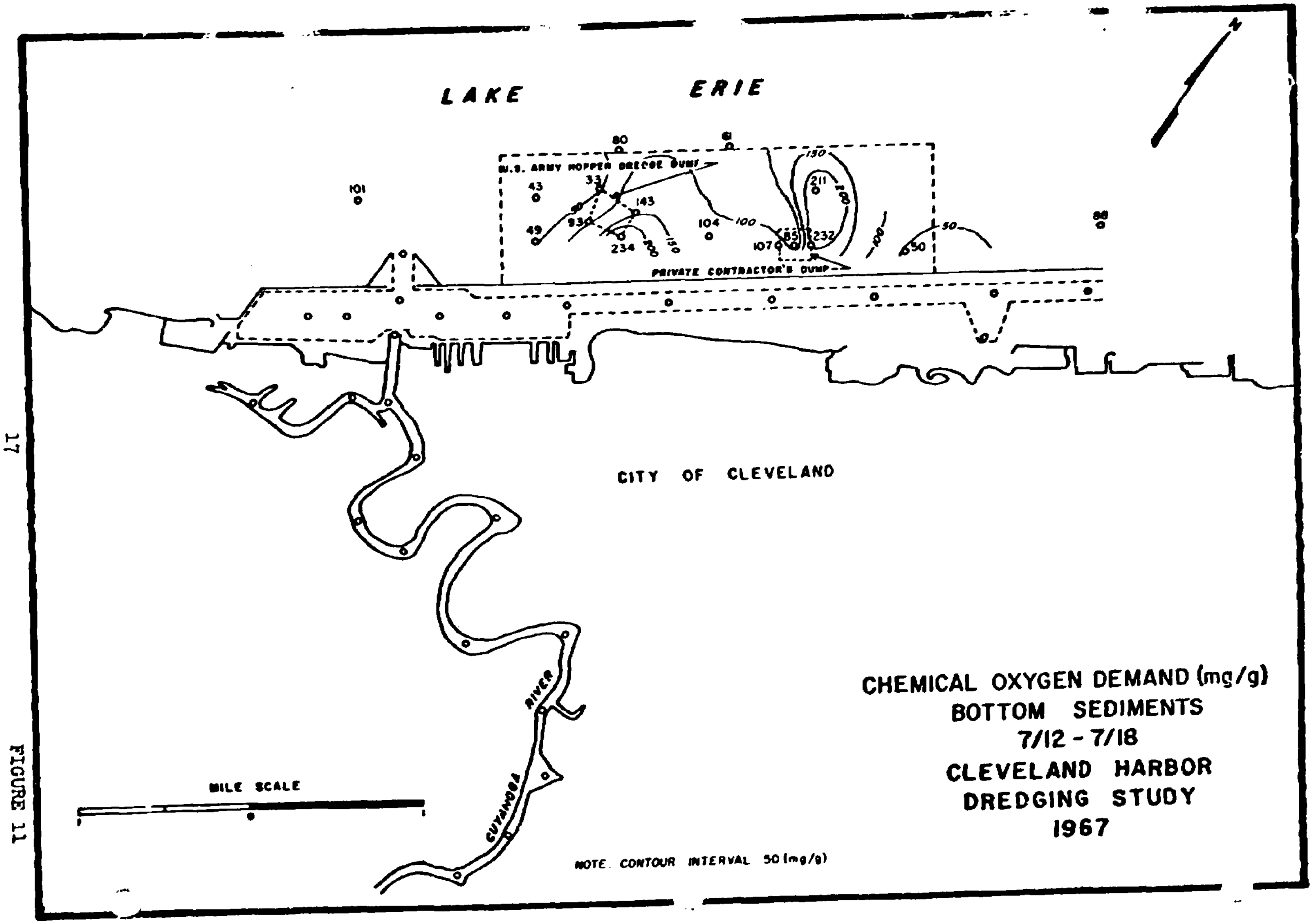

LAKE ERIE
N
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
101
80
61
43
33
143
49
93
234
104
107
85
232
211
50
88
100
150
200
CITY OF CLEVELAND
CUYAHOGA RIVER
MILE SCALE
NOTE. CONTOUR INTERVAL 50 (mg/g)
CHEMICAL OXYGEN DEMAND (mg/g)
BOTTOM SEDIMENTS
7/12 - 7/18
CLEVELAND HARBOR
DREDGING STUDY
1967

FIGURE 11

A hopper load of 850 tons dry weight would contain 108,000 pounds of volatile solids. A total of 25,835,000 pounds was removed in the past year's dredging.

Volatile solids in the dumping ground have a pattern very similar to COD (Figure 6). The river and harbor dump areas were easily identified by volatile solids. These areas had concentrations of the same magnitude as the source areas with the highest concentration in the river dump area.

The background volatile solids concentration in the vicinity of the dumping grounds is in the range of 40 to 50 mg/g.

Biochemical Oxygen Demand

The 5-day biochemical oxygen demand (BOD_5) test on sediments is not considered a very good test as performed for this study. The test involved initial stirring and then quiescence for five days. Results varied widely (Figure 2) in the river sediments and toxicity may have played some part in the scatter. In addition some of the oxygen demand measured here is chemical in nature. The extent is not determiued since IDOD was not measured.

THE BOD_5 of the river sediments, as measured, averaged about 15 mg/g or 30 lbs/ton dry weight. It increased sharply within the lower mile and then climbed gradually to the head of the channel. An average of 30 lbs/ton is approximately equivalent to 18 pounds per cubic yard of in-place sediment. This would give 24,800 pounds per 1350-yard scow load and 14,200,000 pounds total removed during the past year.

BOD_5 values for outer harbor sediments were much more uniform (Figure 4) and averaged about 5 mg/g or 10 lbs/ton. This value would give about 6,350 pounds per hopper dredge load of 850 tons and 1,990,000 pounds removed during the past year.

BOD_5 in the river sediments averaged about 6 percent of the COD and in the harbor about 5-1/4 percent. The profiles of each were similar except in the east part of the outer harbor where COD rises and BOD_5 appears to fall. Chlorine demand was also higher in that area.

In the dumping ground BOD_5 was widely variable but the pattern was similar to COD (Figure 6). The actual dump sites showed higher BOD and the river dump the highest. Figures 12 through 16 show areal variations of BOD_5 in the dump sediments with time.

Oil and Grease

Oils and greases are the constituents of the Cleveland harbor sediments which cause the most offensive appearance. They were measured for this investigation by hexane extraction.

In the Cuyahoga River navigation channel oil and grease content is high (Figure 3). In the lower mile of the river the concentration climbs sharply from 5 mg/g to 25 mg/g of dry weight. In the next mile it remains relatively constant and then climbs to about 45 mg/g. In the upper mile of the navigation channel the oil concentration falls to about 35 mg/g. An average for the river would be about 35 mg/g or 70 lbs/ton of sediment dry weight. This is equivalent to about 42 pounds per cubic yard of in-place sediment or 56,360 pounds per dredging scow load. Extending this rate, 32,270,000 pounds were removed

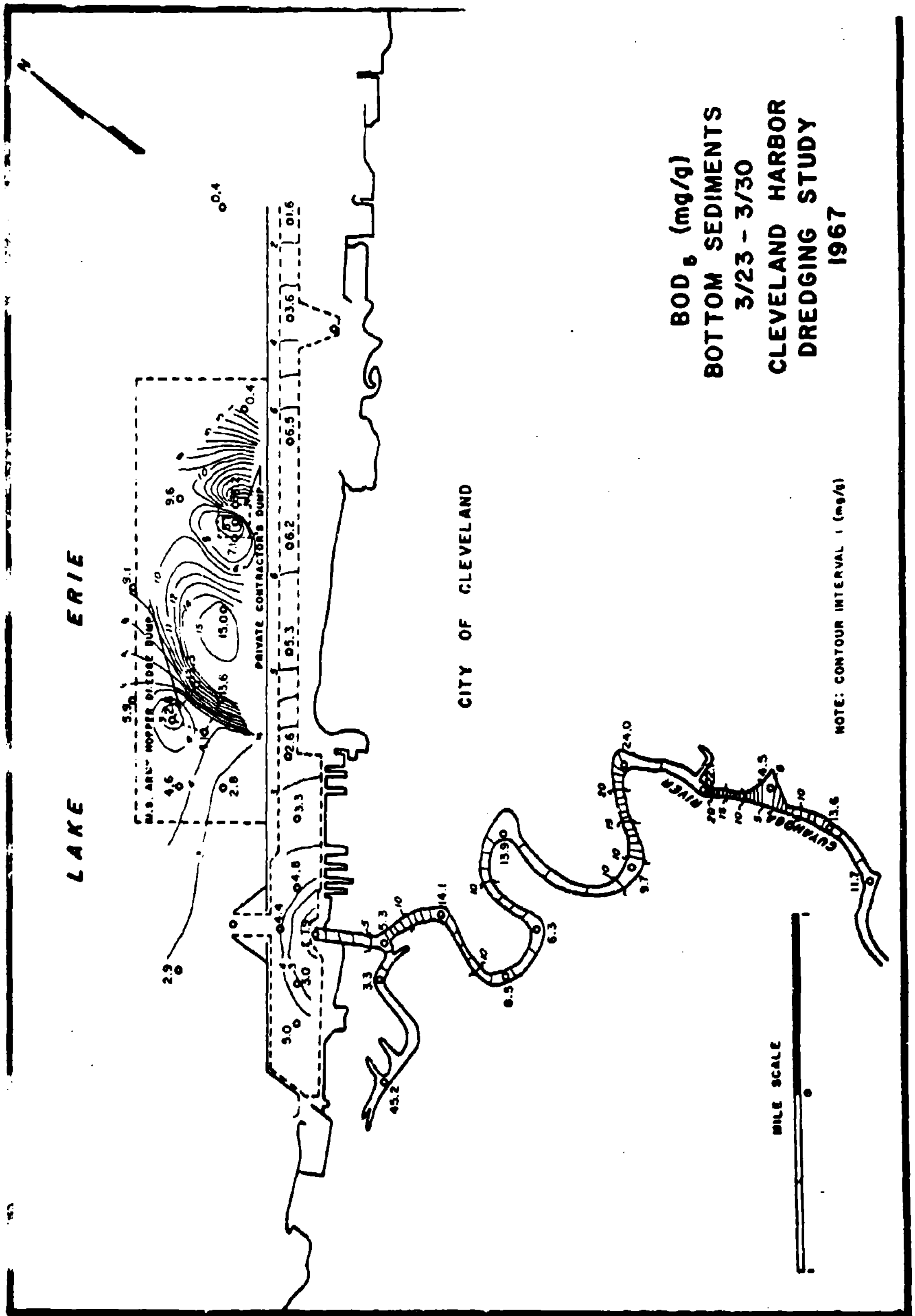

BOD$_5$ (mg/g)
BOTTOM SEDIMENTS
3/23 - 3/30
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
NOTE: CONTOUR INTERVAL 1 (mg/g)
MILE SCALE

FIGURE 12

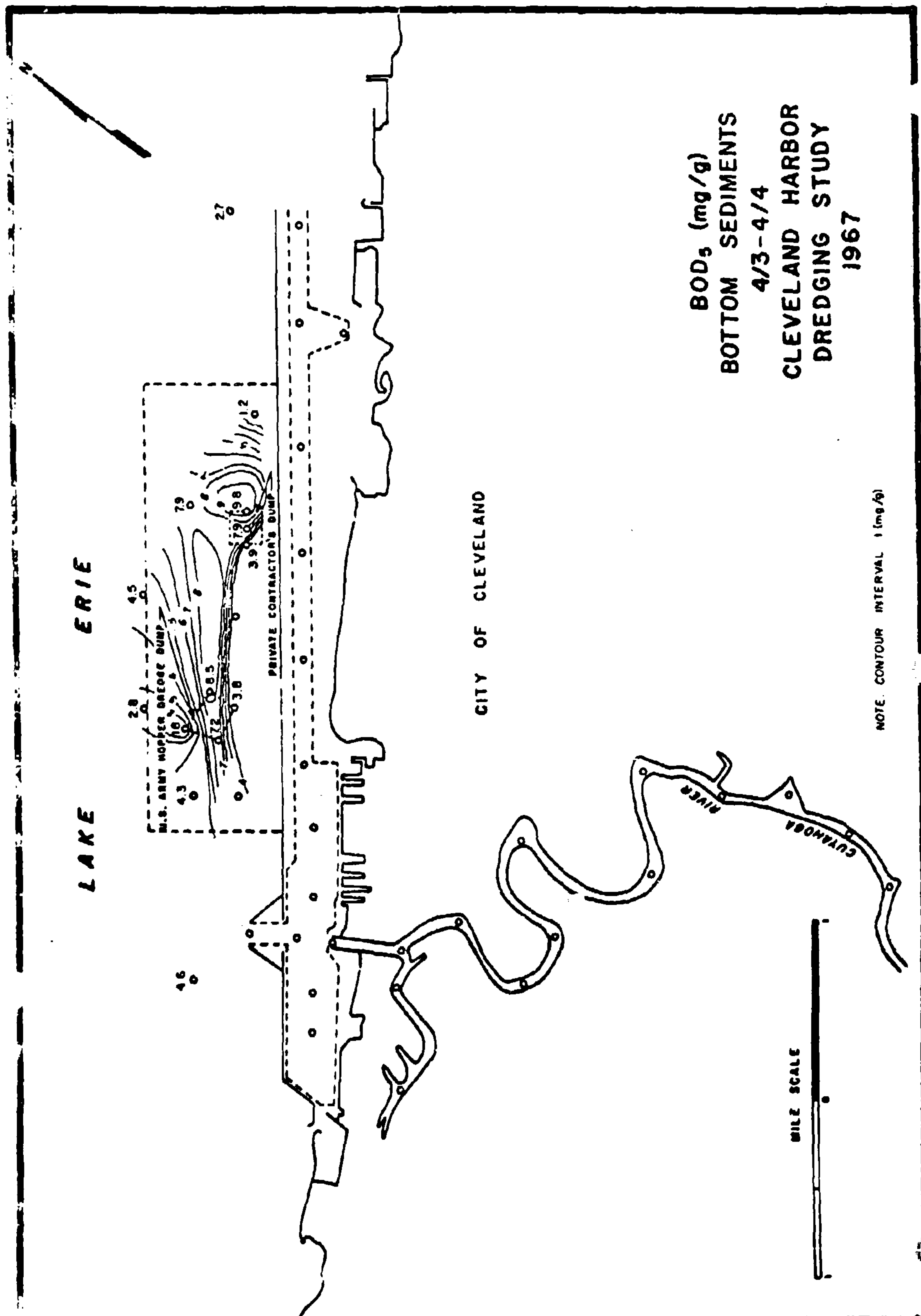

N
LAKE ERIE
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CITY OF CLEVELAND
CUYAHOGA RIVER
BOD5 (mg/g)
BOTTOM SEDIMENTS
4/3-4/4
CLEVELAND HARBOR
DREDGING STUDY
1967
NOTE: CONTOUR INTERVAL 1 (mg/g)
MILE SCALE

FIGURE 13

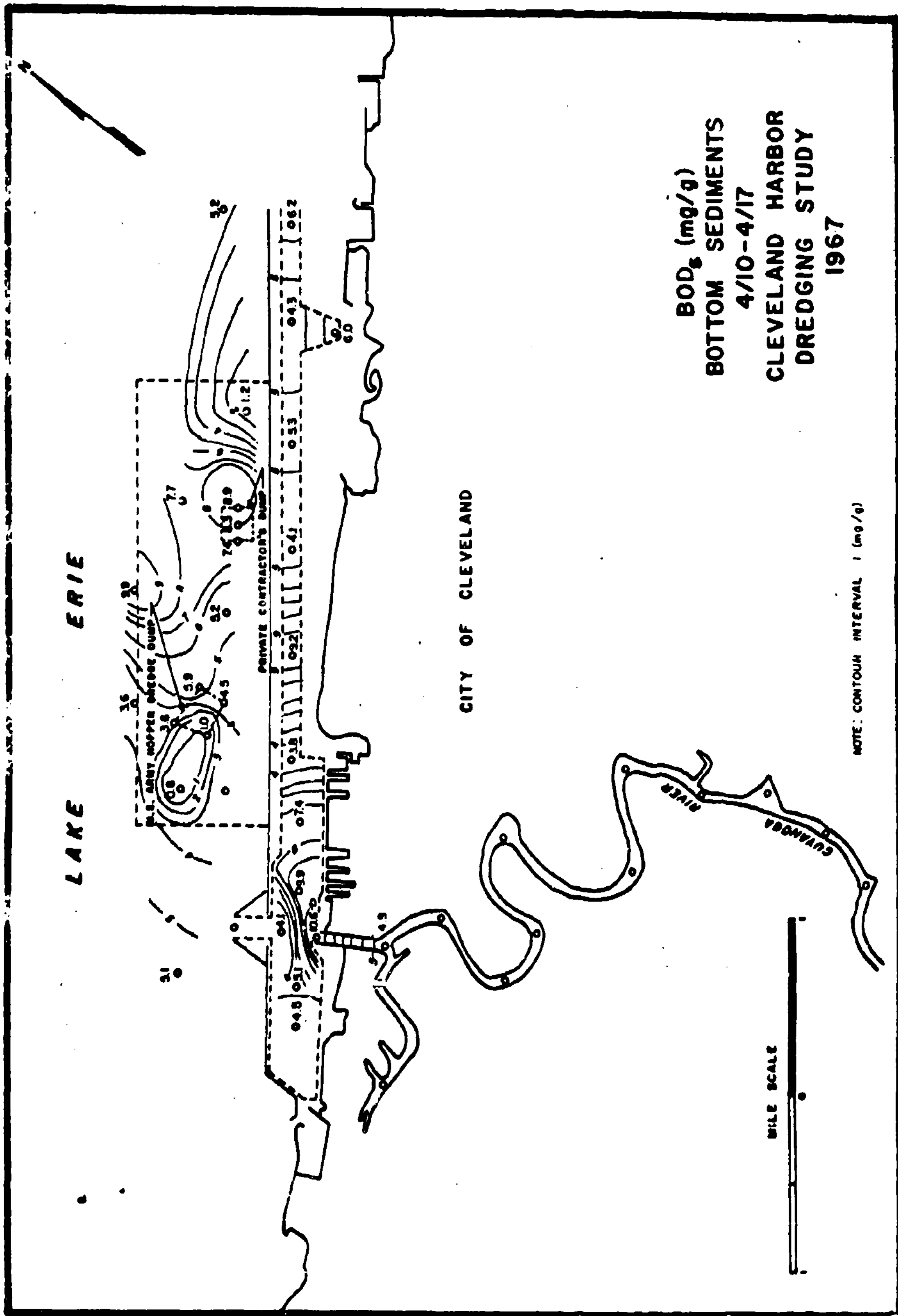
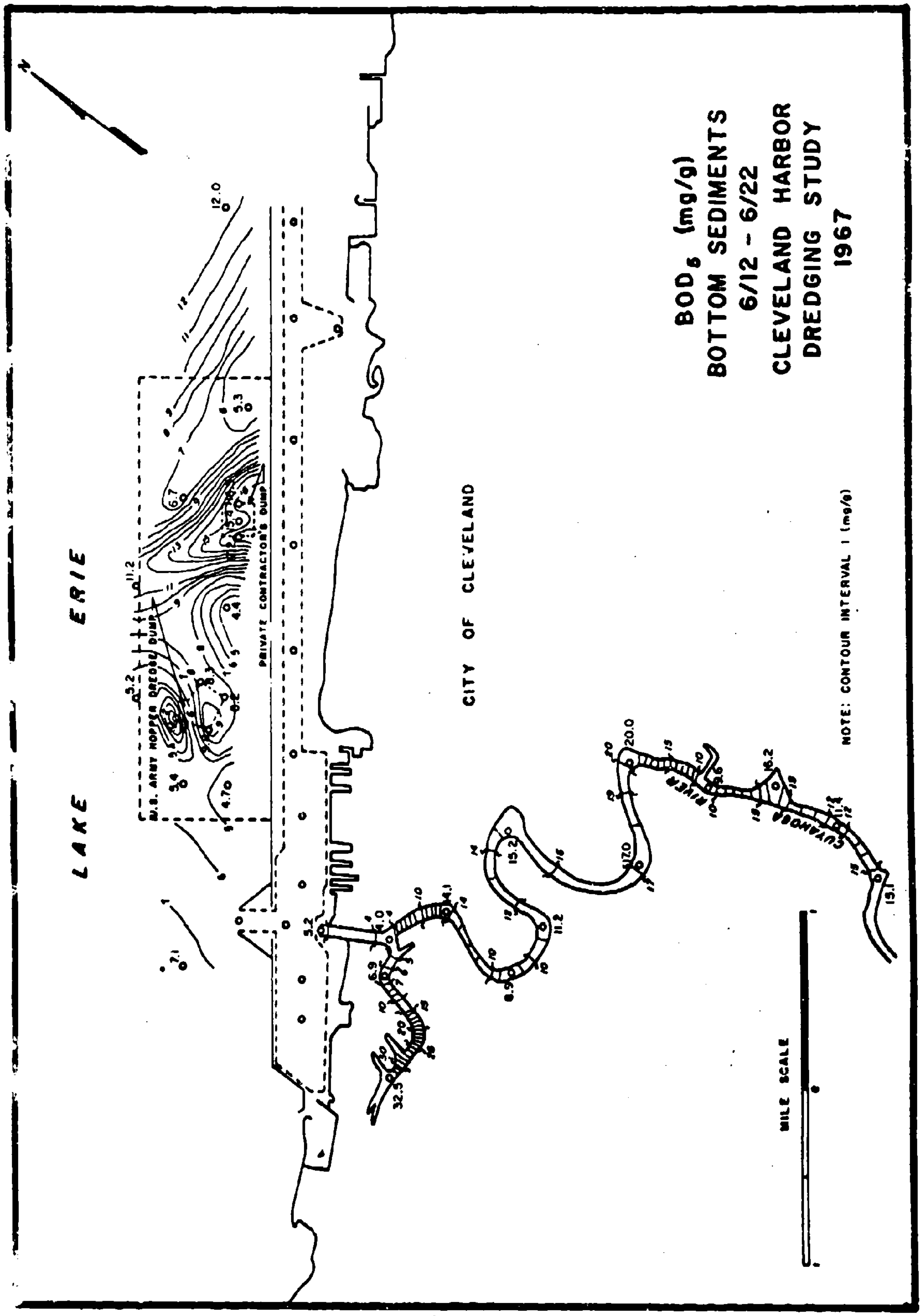
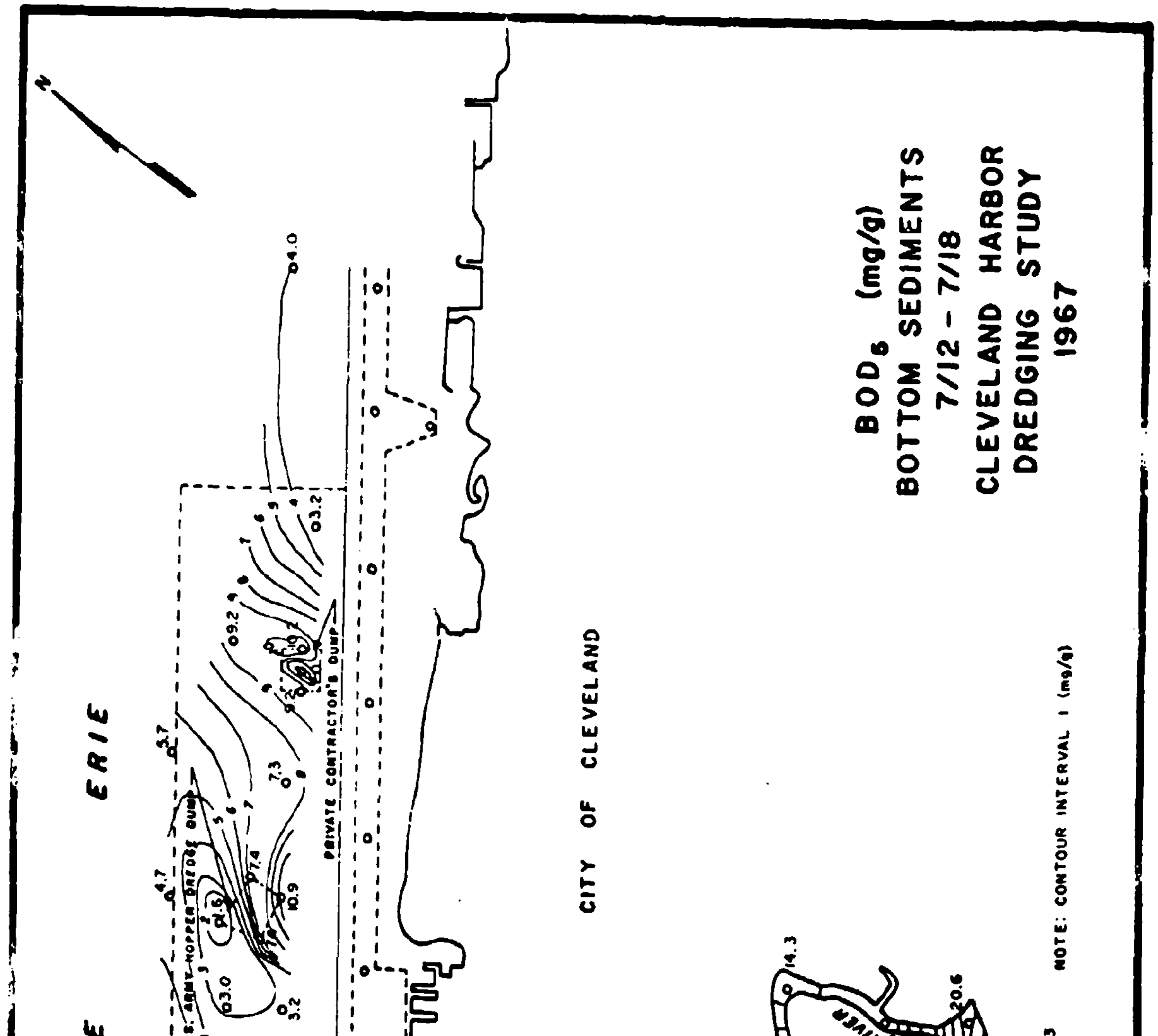

BOD$_5$ (mg/g)
BOTTOM SEDIMENTS
4/10-4/17
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
CUYAHOGA RIVER
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
NOTE: CONTOUR INTERVAL 1 (mg/g)
MILE SCALE

FIGURE 14



BOD5 (mg/g)
BOTTOM SEDIMENTS
6/12 - 6/22
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
NOTE: CONTOUR INTERVAL 1 (mg/g)
MILE SCALE

FIGURE 15



BOD5 (mg/g)
BOTTOM SEDIMENTS
7/12 - 7/18
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
MILE SCALE
NOTE: CONTOUR INTERVAL 1 (mg/g)
4.0
3.2
9.2
7.3
3.7
4.7
7.4
10.9
3.0
3.2
3.8
16.8
16.0
12.7
11.6
10.6
14.3
13.3
20.6
26.3
22.4

FIGURE 16

from the river in the past year by dredging.

The oil and grease content of the outer harbor sediments is much lower (Figure 5), averaging about 8 mg/g dry weight or 16 lbs/ton. This concentration would give 13,600 pounds per hopper dredge load of 850 tons and 3,170,000 pounds for the past year's dredging. This is only about one-tenth the quantity removed from the river.

Oil and grease content in the dumping ground (Figure 7) reflects the disposal of dredged material, with higher content in the two actual areas of 1967 dumping. The background level appears to be less than 4 mg/g but in the dumping ground it climbs to more than 30 mg/g. The resistance of hydrocarbon oils to breakdown has apparently resulted in a general build-up of oil and grease in this area from dredging of past years. The background level of 4 mg/g is much higher than the level in midlake of less than 0.5 mg/g. Figures 17 and 18 show the areal patterns of oil concentration in March and July, 1967. High levels in the hopper dredging dump (Figure 17) indicate the source to be the river, but river sediments were not dumped there this year.

Phosphorus

River sediment phosphorus concentrations (Figures 3 and 19) are lowest at the river mouth, rising to a point 3.5 miles upstream, then declining farther upstream. River sediments averaged about 4 mg/g or 8 lbs/ton dry weight phosphorus. This is equivalent to 4.8 pounds per cubic yard of in-place sediment or 6,480 pounds per 1350 cubic yard scow load.

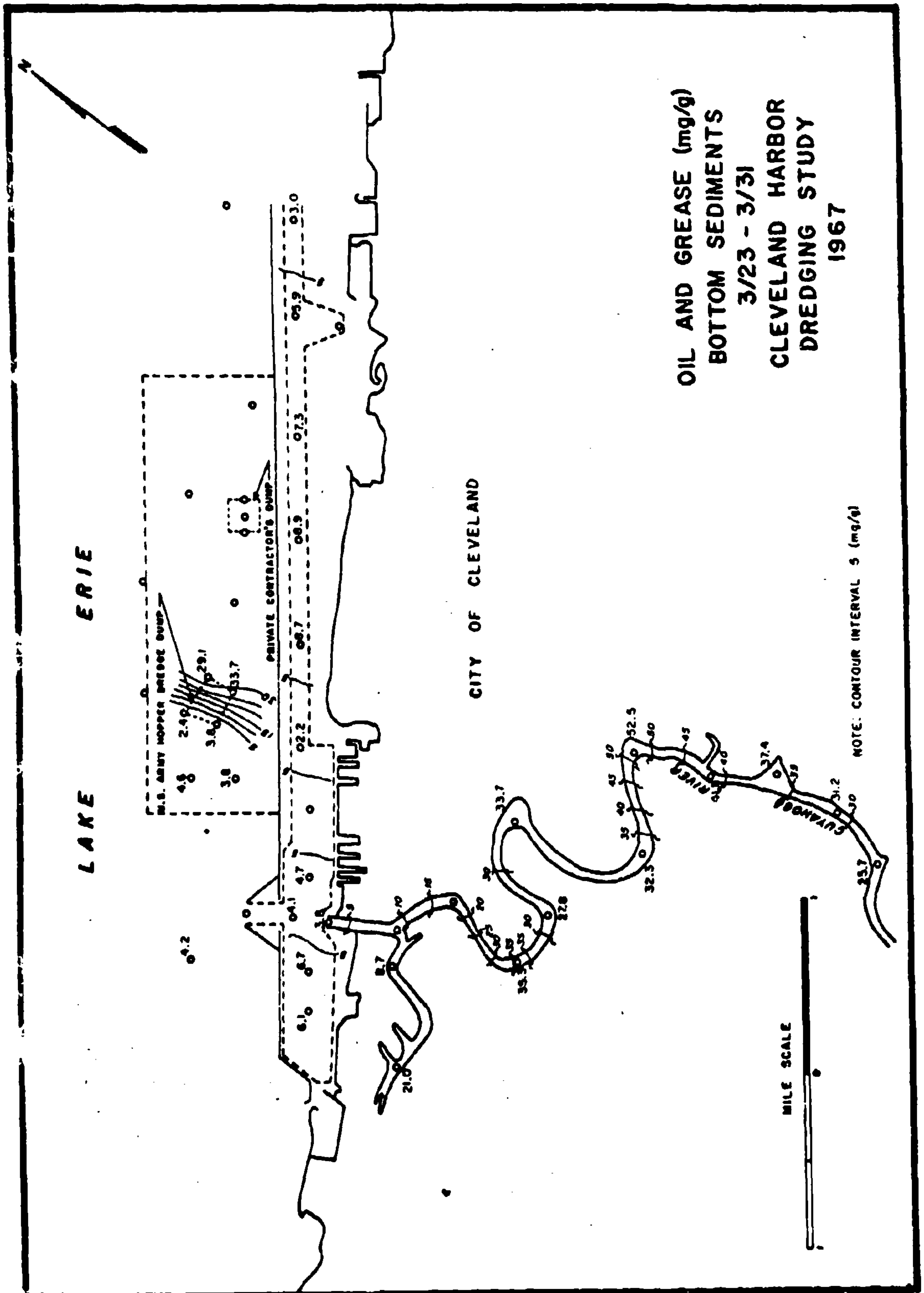

OIL AND GREASE (mg/g)
BOTTOM SEDIMENTS
3/23 - 3/31
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
NOTE: CONTOUR INTERVAL 5 (mg/g)
MILE SCALE

FIGURE 17

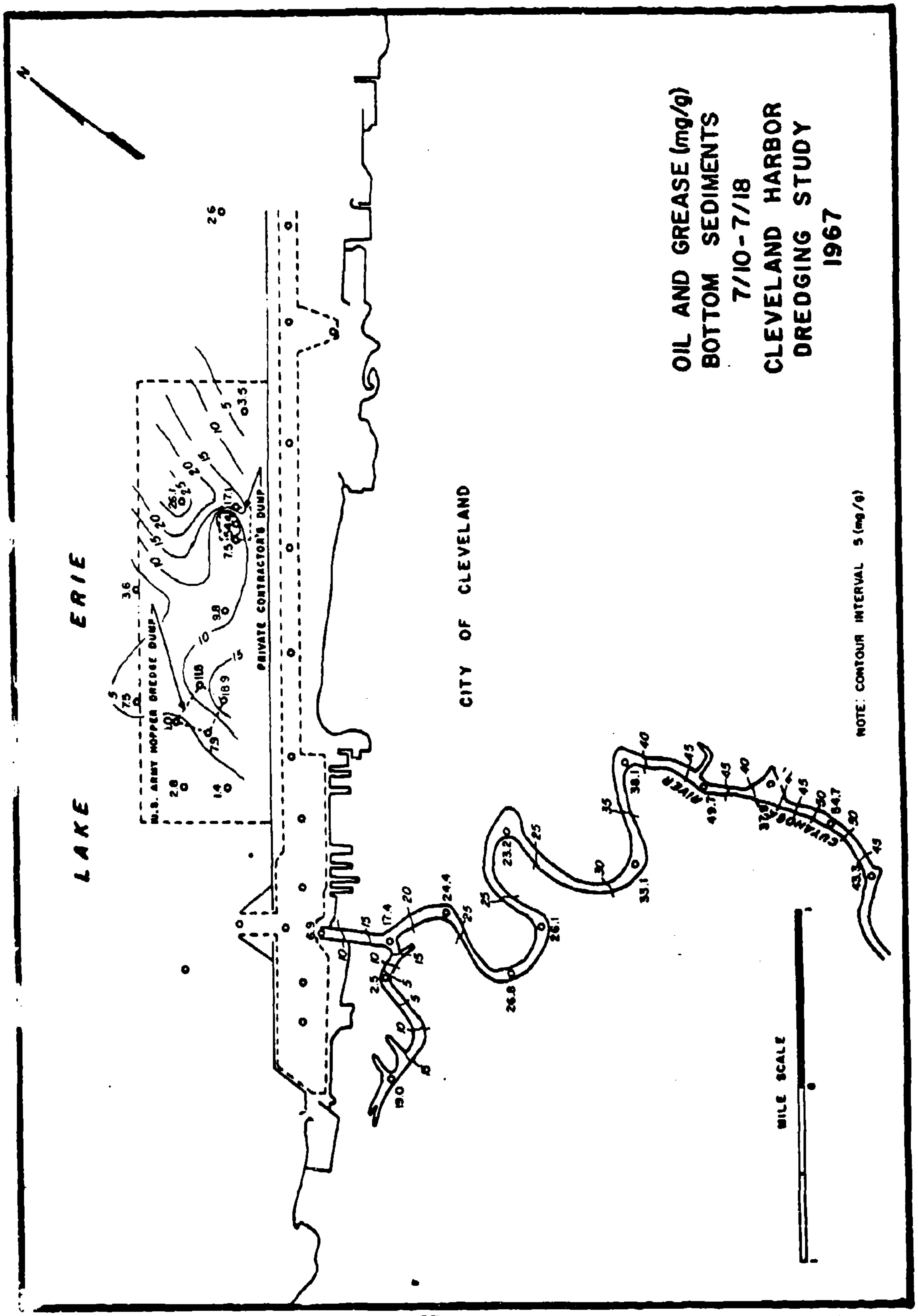

OIL AND GREASE (mg/g)
BOTTOM SEDIMENTS
7/10-7/18
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
NOTE: CONTOUR INTERVAL 5 (mg/g)
MILE SCALE

FIGURE 18

Thus 3,710,000 pounds have been removed in the past year from river dredging. This is equivalent to nearly all of the known phosphorus discharges to the Cuyahoga River.

The phosphorus level in the outer harbor sediments (Figure 5) was fairly constant, averaging about 1.5 mg/g or 3 lbs/ton dry weight. Thus a 850-ton hopper would contain 2,550 pounds and 596,000 pounds were removed by hopper dredging in the past year.

Only a few phosphorus analyses of dumping area sediments have been made (Figure 19) although more will be made. Higher values in the hopper dump indicated the presence of both river and outer harbor sediments.

Nitrogen

Total nitrogen in the Cuyahoga River sediment was time-variable. The first samples in March 1967 showed much higher nitrogen content, especially ammonia, than later samples, probably because of slower breakdown of ammonia in winter, resulting in accumulation.

The average total nitrogen content for all sampling in the river was about 5 mg/g or 10 lbs/ton and the content rose upstream (Figure 3). This figure may be low for estimating removal because much of the material was removed when concentrations were higher. Assuming however that the average concentration in removed sediment was 5 mg/g, the concentration per cubic yard of in-place sediment was about 6.0 pounds. This gives a total of 4,647,000 pounds removed during the past year.

In the harbor the nitrogen concentration was more uniform, and much lower (Figure 5), averaging 1.6 mg/g dry weight or 3.2 lbs/ton. A 800-ton hopper load would contain 2,560 pounds. This rate applied

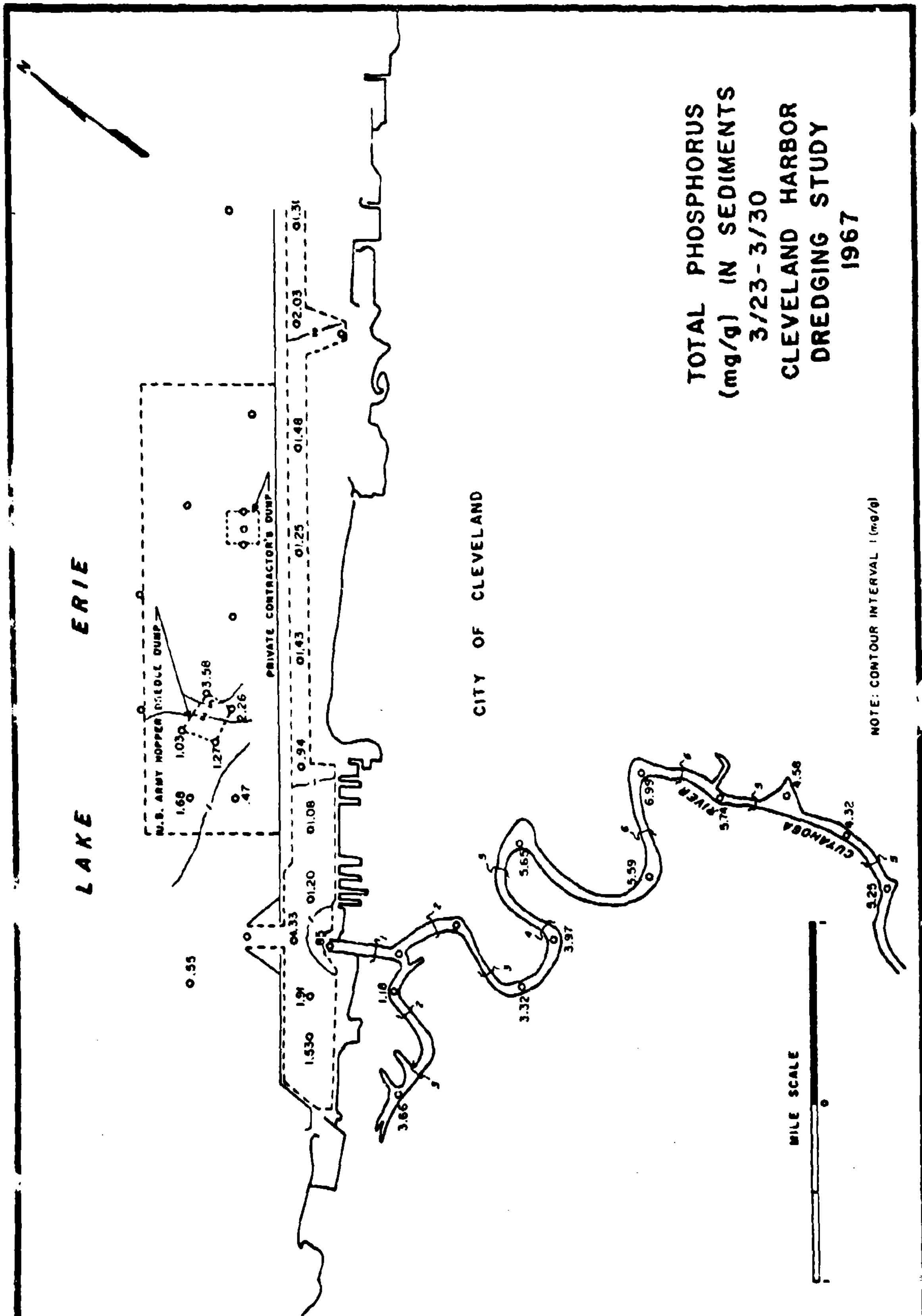

TOTAL PHOSPHORUS
(mg/g) IN SEDIMENTS
3/23-3/30
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
CUYAHOGA RIVER
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
NOTE: CONTOUR INTERVAL 1 (mg/g)
MILE SCALE

FIGURE 19

to the past year's dredging gives 636,000 pounds removed for that period.

Total nitrogen in the dumping ground varied considerably with time (Figures 20 through 24). The river dump is most apparent (Figure 7), and the hopper dredge dump became less conspicuous with time in regard to nitrogen (Figures 22 and 23).

Total Iron

The iron content of the river sediments is high. Only samples taken on the first sampling run have been analyzed for iron, but those analyses showed an average concentration of about 110 mg/g or 220 lbs/ton dry weight above one mile from the mouth (Figure 3). Near the mouth the concentration drops to about 30 mg/g. Using an average of 110 mg/g or132 pounds per cubic yard of in-place sediment, a scow load contains 178,000 pounds of iron and 101,980,000 pounds were removed from the river in the past year.

Iron content of the outer harbor sediments averaged about 45 mg/g or 90 lbs/ton dry weight (Figure 5). This gives 76,500 pounds per 850-ton hopper load and 17,885,000 pounds for the past year.

Total iron in the dumping ground sediments shows dramatically the effect of dumping (Figure 7). Concentrations exceeded those found in the harbor area with several samples above 150 mg/g (Figures 25 and 26). These higher concentrations may result from winnowing of lighter materials.

Silica

The amount of silica in the sediment is an indication of the contribution of inorganic land runoff. It is in general inversely related

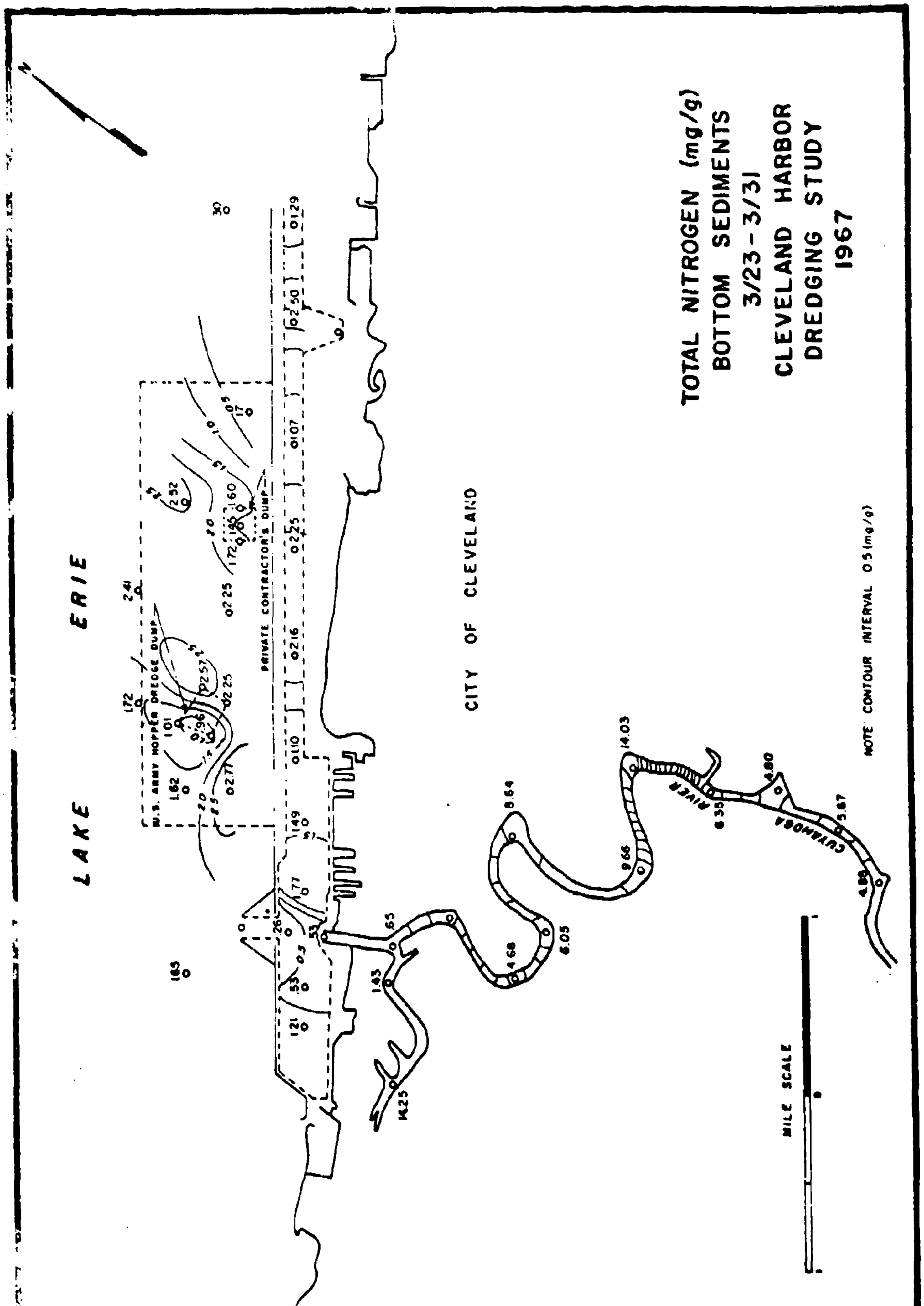

TOTAL NITROGEN (mg/g)
BOTTOM SEDIMENTS
3/23 - 3/31
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
MILE SCALE
NOTE: CONTOUR INTERVAL 0.5 (mg/g)

FIGURE 20

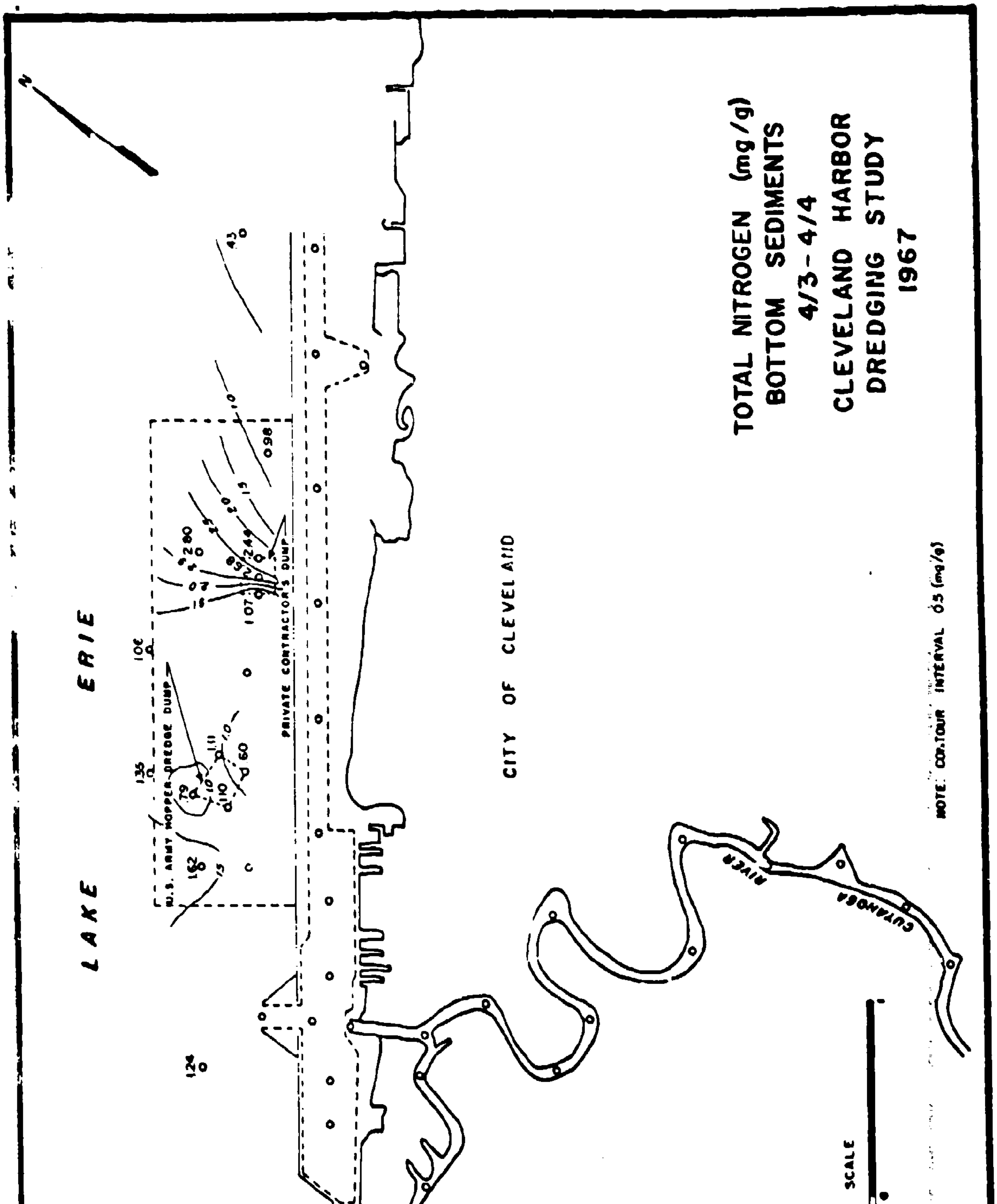

TOTAL NITROGEN (mg/g)
BOTTOM SEDIMENTS
4/3 - 4/4
CLEVELAND HARBOR
DREDGING STUDY
1967
N
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
MILE SCALE
NOTE: CONTOUR INTERVAL 0.5 (mg/g)

FIGURE 21

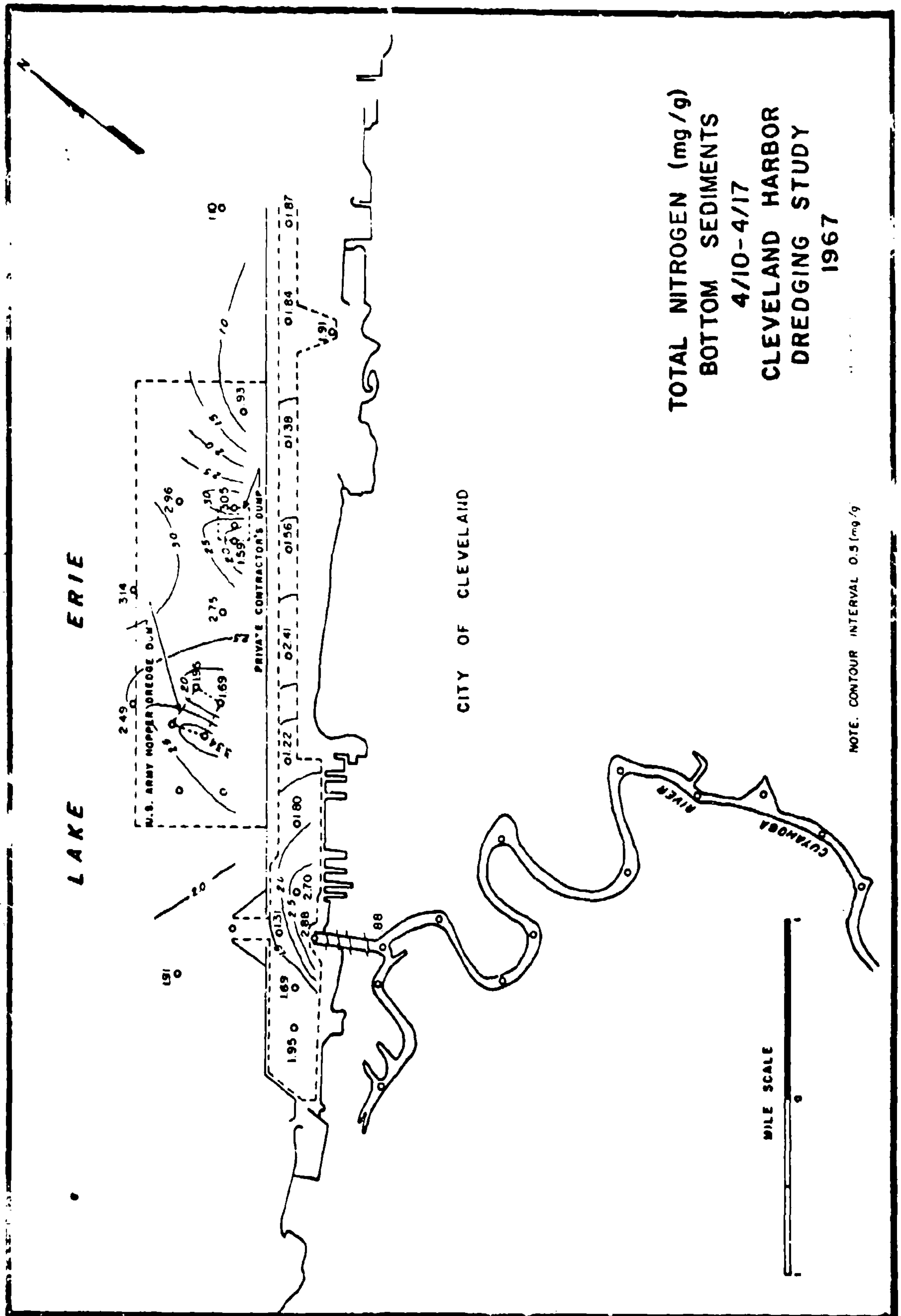

TOTAL NITROGEN (mg/g)
BOTTOM SEDIMENTS
4/10-4/17
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
MILE SCALE
NOTE. CONTOUR INTERVAL 0.5 (mg/g)

FIGURE 22

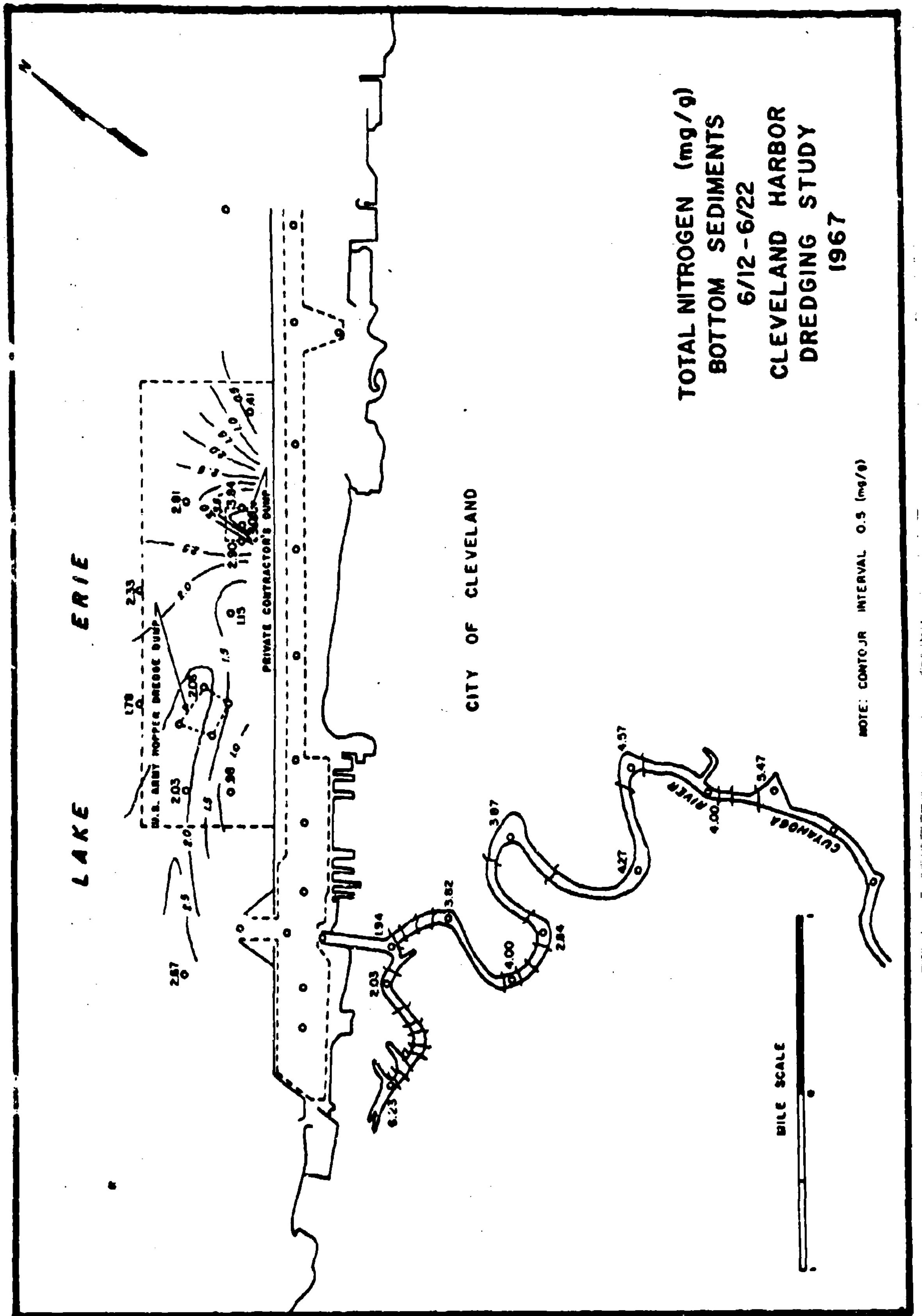

TOTAL NITROGEN (mg/g)
BOTTOM SEDIMENTS
6/12-6/22
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
NOTE: CONTOUR INTERVAL 0.5 (mg/g)
MILE SCALE

FIGURE 23

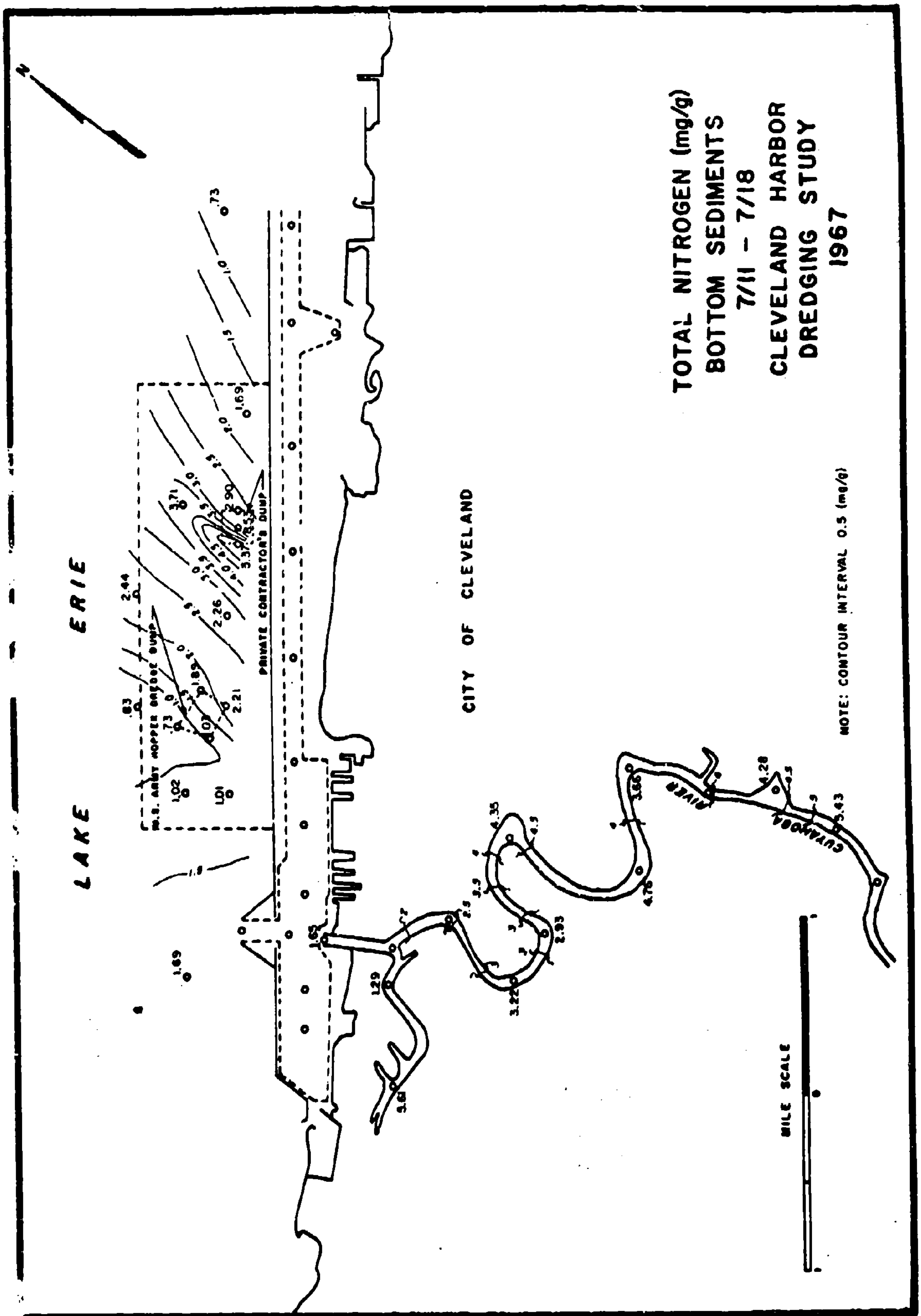

TOTAL NITROGEN (mg/g)
BOTTOM SEDIMENTS
7/11 - 7/18
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
NOTE: CONTOUR INTERVAL 0.5 (mg/g)
MILE SCALE

FIGURE 24

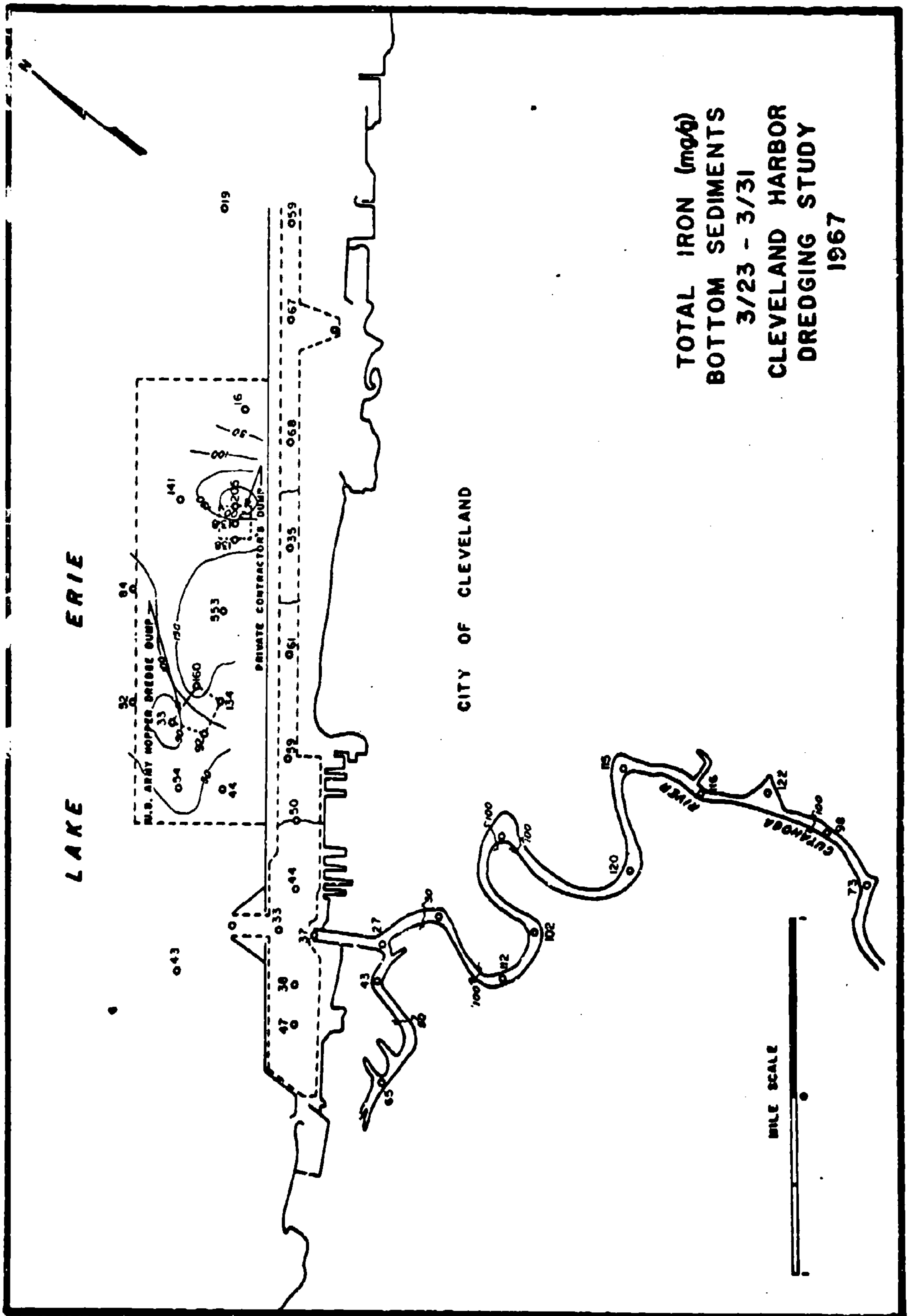

TOTAL IRON (mg/g)
BOTTOM SEDIMENTS
3/23 - 3/31
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
MILE SCALE

FIGURE 25

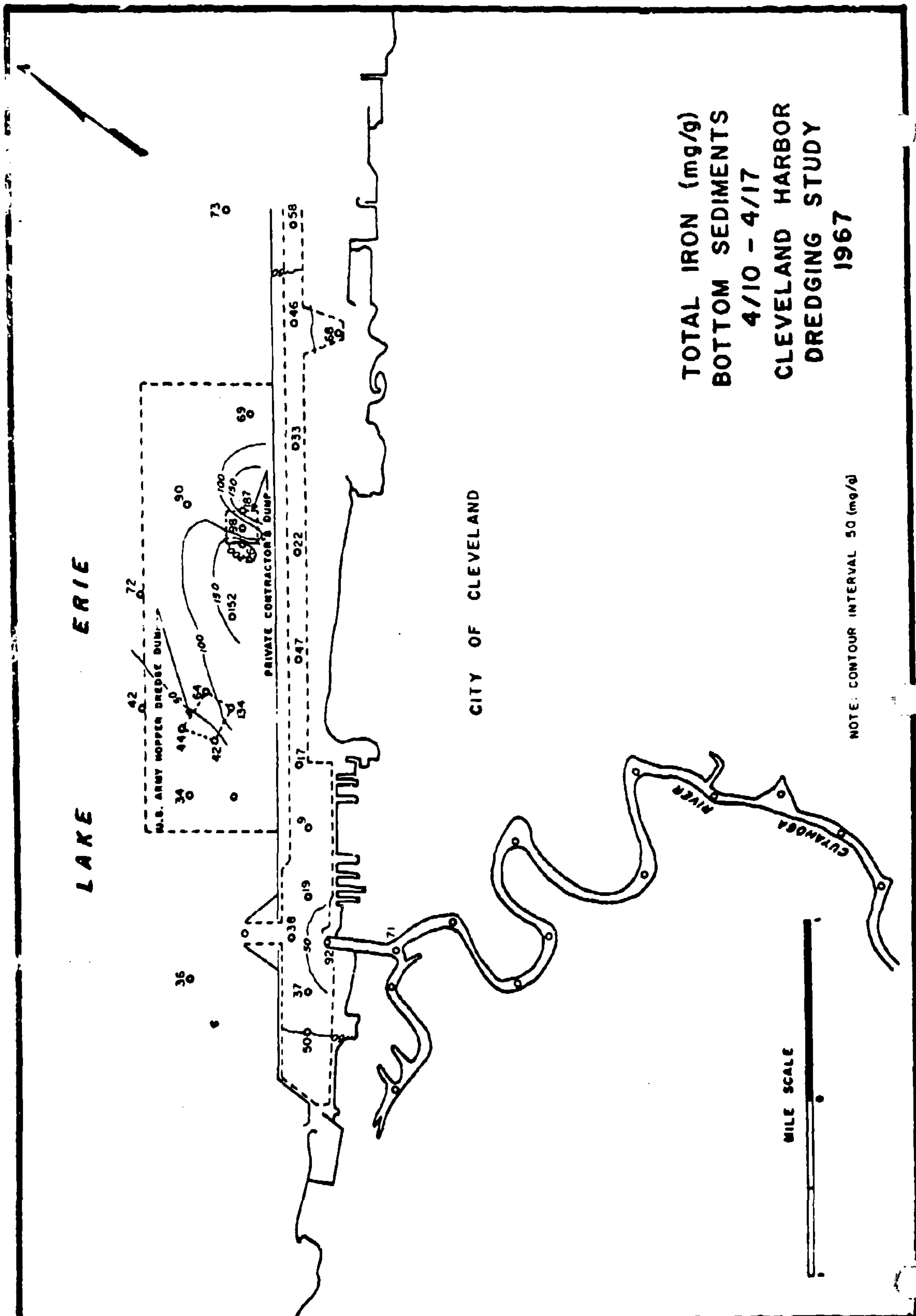

TOTAL IRON (mg/g)
BOTTOM SEDIMENTS
4/10 - 4/17
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
NOTE: CONTOUR INTERVAL 50 (mg/g)
MILE SCALE

FIGURE 26

to volatile solids content in this area. The river sediments average about 550 mg/g dry weight and the outer harbor 720 mg/g. The lake bottom in the vicinity of, but outside the dumping ground appears to generally exceed 800 mg/g. Silica concentrations are shown in Figure 27.

Sediment Load Summary

Table 2 summarizes the loading to Lake Erie of various constituents as a result of dredging during the past year.

TABLE 2

LOADINGS TO LAKE ERIE FROM CLEVELAND HARBOR AND RIVER DREDGING - 7/1/66 to 7/1/67

	River (tons)	Harbor (tons)	Total (tons)
Chemical Oxygen Demand	110,000	19,000	119,000
BOD_5	7,100	1,000	8,100
Chlorine Demand (15 min.)	14,000	2,400	16,400
Volatile Solids	58,000	13,000	71,400
Oil and Grease	16,000	1,600	17,600
Phosphorus	1,860	300	2,160
Nitrogen	2,300	320	2,620
Iron	51,000	9,000	60,000
Silica	270,000	140,000	410,000
Total dry solids	460,000	200,000	660,000

It has been stated that dredging carries materials to the lake which would eventually be transported to the lake naturally. This is not a valid assumption and could not be until after the deepened harbor had filled to its natural sediment level at essentially the level which existed before the artificial channels were dredged.

The Corps of Engineers reports some 15 million cubic yards of

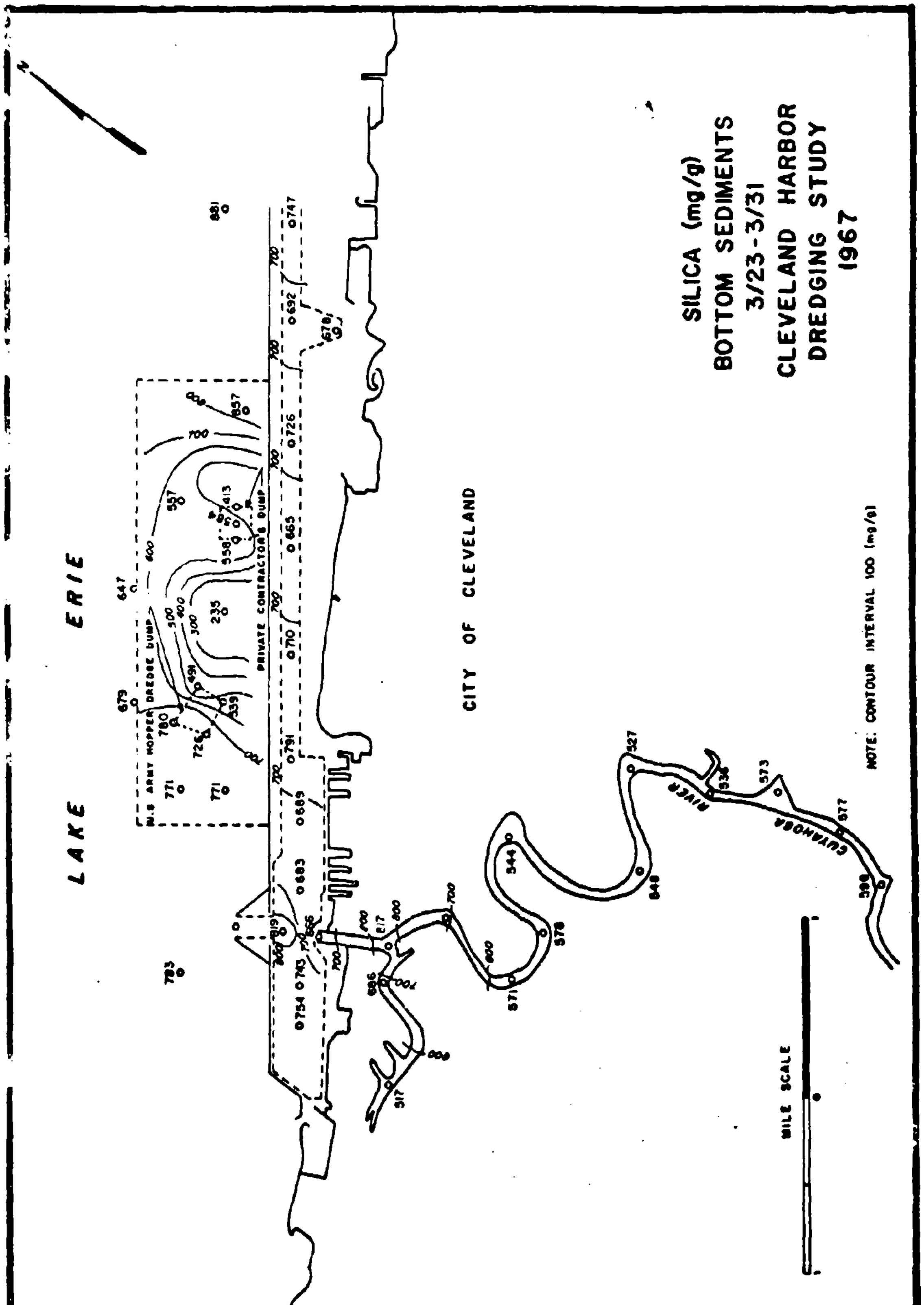

SILICA (mg/g)
BOTTOM SEDIMENTS
3/23-3/31
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
CUYAHOGA RIVER
PRIVATE CONTRACTOR'S DUMP
U.S. ARMY HOPPER DREDGE DUMP
MILE SCALE
NOTE: CONTOUR INTERVAL 100 (mg/g)

FIGURE 27

material removed from Cleveland Harbor during the past ten years, more than half of which was removed from the river portion of the harbor. Cleveland Harbor requires more volume of maintenance dredging than any other harbor on the Great Lakes.

Silica accounts for about 59 percent of the total solids (by weight) in the river sediments and 70 percent in the harbor sediments. This indicates that one-half or more of the total sediment is derived from runoff.

Table 3 compares the average concentrations of sediment constituents in the river, outer harbor, dumping grounds, and central Lake Erie. Analyses of midlake sediments made in 1963 are used in this comparison.

Note that apparent inconsistencies occur in volatile solids and in total iron. Concentrations in the scow dump exceed those in both the river and harbor. Also note the similarities between Outer Harbor and midlake sediments with the exceptions of oil and great and COD.

TABLE 3

AVERAGE CONCENTRATION COMPARISON FOR VARIOUS AREAS
(mg/g dry weight)

Constituent	River	Outer Harbor	Entire dump area	Hopper Dump	Scow Dump	Central Lake Erie
Chlorine demand	30	12	--	--	--	--
COD	240	95	107	106	178	41
BOD_5	15	5	7	6	10	1
Volatile Solids	125	65	71	67	140	63
Oil and Grease	35	8	9	10	15	0.4
Phosphorus	4	1.5	1.8	2.2	2.5	0.7
Nitrogen	5	1.6	1.9	1.6	2.7	1.9
Iron	110	45	92	90	150	35
Silica	550	720	645	655	535	--

Benthic Biology

Wherever benthic organisms have been found, sludgeworms were by far the most predominant and they were essentially the only organisms found in the river.

Benthic organisms (sludgeworms) were present in very low numbers in the river in March 1967 (Figure 28). Their numbers increased slightly at the upper end of the navigation channel and greatly near the river mouth. By July there were no benthic organisms in the river except in the lower half mile. Depletion of dissolved oxygen may account for their disappearance. Their near-absence in March suggests the possibility of toxic substances in the sediments.

Benthic organisms in the outer harbor in March and April were rather abundant (Figures 28 and 29). Sludgeworms were overwhelmingly dominant, but significant numbers of fingernail clams and a few snails were also present.

Changes in benthic populations between March and July in the dumping ground sediments were dramatic (Figures 28, 29, and 30). In March the populations were similar to the outer harbor, in early April they were much higher; in July the populations were severely reduced. Comparison of Figures 29 and 30 indicates that initial dredge dumping may have increased populations but that continued dredging (mainly river sediment) was highly detrimental to benthos, perhaps by smothering or by introduction of toxicants.

WATER ANALYSIS

It is difficult to show significant lasting effects on water

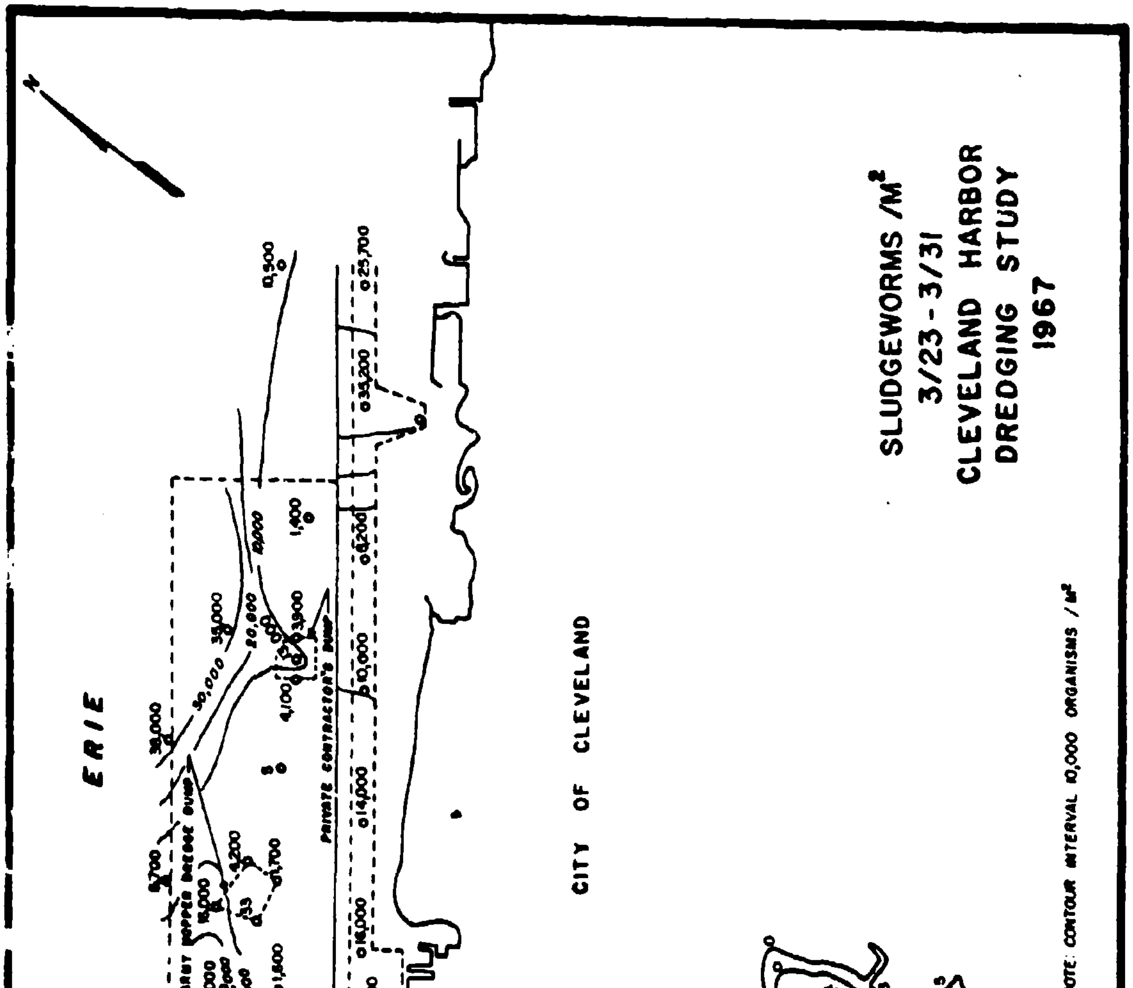

SLUDGEWORMS /M²
3/23 - 3/31
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
CUYAHOGA RIVER
NOTE: CONTOUR INTERVAL 10,000 ORGANISMS / M²
MILE SCALE

FIGURE 28

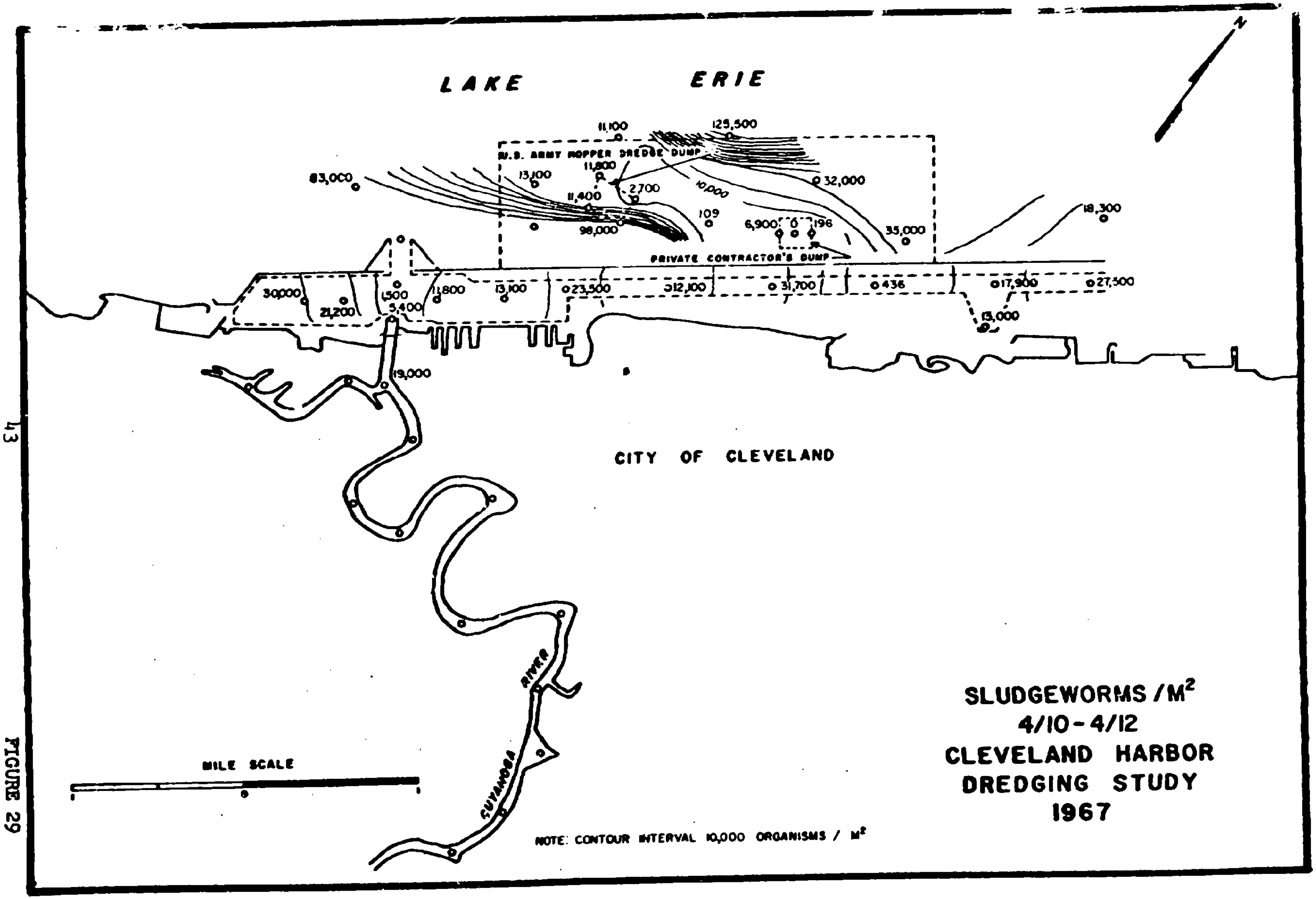

LAKE ERIE
N
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
11,100
125,500
83,000
13,100
11,800
2700
11,400
10,000
32,000
109
6,900
196
98,000
35,000
18,300
30,000
21,200
1,500
5,400
11,800
13,100
23,500
12,100
31,700
436
17,900
27,500
13,000
19,000
CITY OF CLEVELAND
CUYAHOGA RIVER
MILE SCALE
SLUDGEWORMS / M²
4/10 - 4/12
CLEVELAND HARBOR
DREDGING STUDY
1967
NOTE: CONTOUR INTERVAL 10,000 ORGANISMS / M²

FIGURE 29

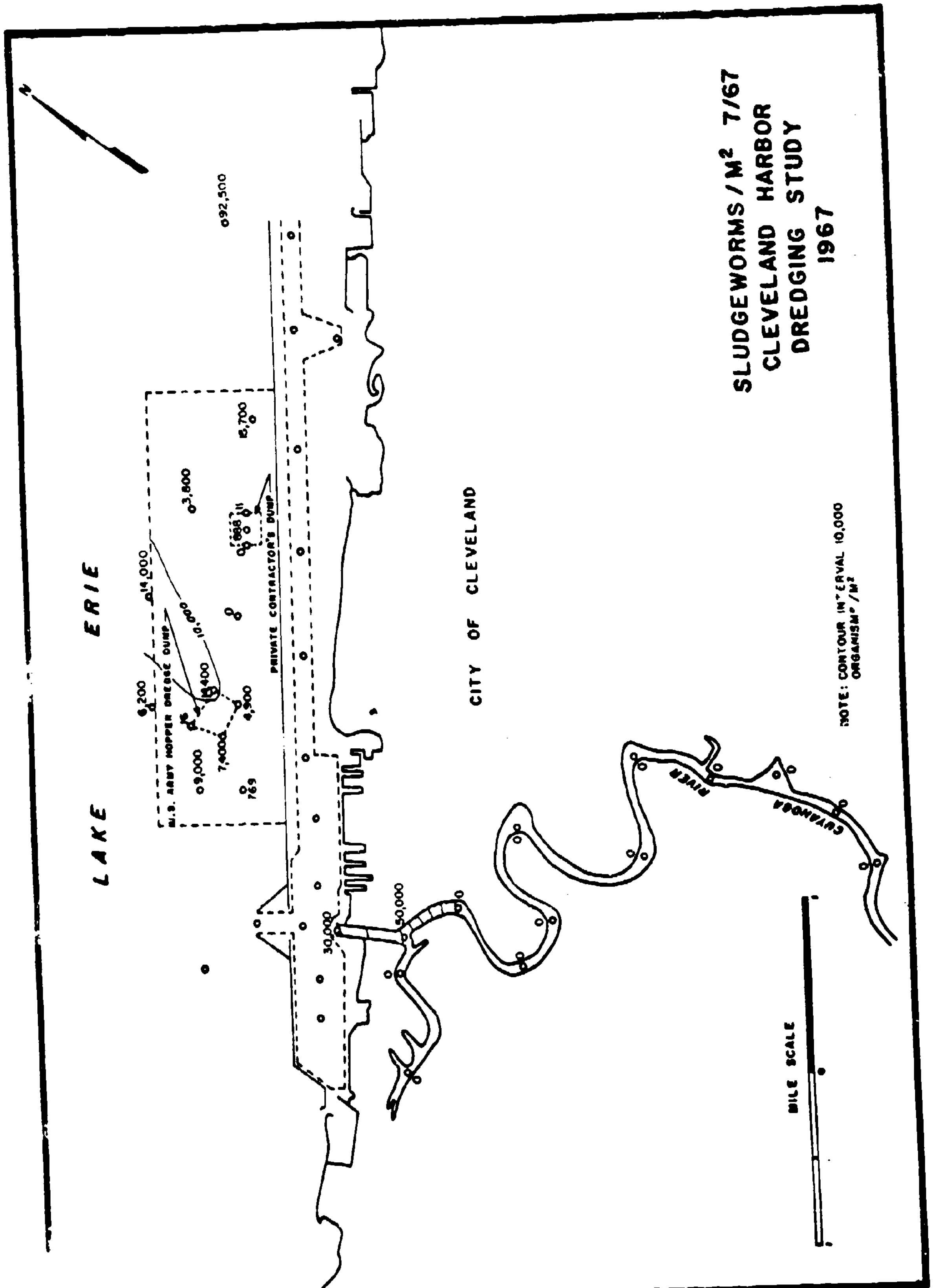

SLUDGEWORMS / M² 7/67
CLEVELAND HARBOR
DREDGING STUDY
1967
LAKE ERIE
CITY OF CLEVELAND
PRIVATE CONTRACTOR'S DUMP
U.S. ARMY HOPPER DREDGE DUMP
CUYAHOGA RIVER
92,500
15,700
3,800
14,000
10,000
6,200
8,400
4,500
7,400
9,000
769
30,000
50,000
NOTE: CONTOUR INTERVAL 10,000 ORGANISMS/M²
MILE SCALE

FIGURE 30

quality in the vicinity of dredging and dumping. Temporary local effects occur such as depression of dissolved oxygen levels and increase of suspended solids. For example oxygen levels were depressed by as much as 25 percent in the area of hopper dredging and by up to 35 percent near the bottom in the scow dump area. Suspended solids in these areas ran up to 200 mg/l where normally they would be less than 50 mg/l.

Other chemical parameters of the water anywhere in the study area were not out of the range expected in the absence of dredging. The same conclusion also applies to microbiological and biological parameters. Of course to be considered is the fact that background values of most of these are relatively high. If the dump area were farther out in the lake it is likely that effects on water would be more readily apparent.

Table 4 lists the ranges of some chemical and microbiological constituents in the waters of the river, the outer harbor, the dumping ground, and midlake. As expected, there is a general decline lakeward in the concentration of most constituents.

Total phosphorus and soluble phosphorus in the river water are very low compared to the quantities being discharged to the river. Since phosphorus concentrations in the river sediments are remarkably high, precipitation must be occurring in the navigation channel. It is assumed that iron-bearing waters discharged primarily by steel plants cause the precipitation.

TABLE 4

CONCENTRATION RANGES OF WATER CONSTITUENTS

Constituent	River	Outer Harbor	Dumping Ground	Central Lake
Total P mg/l	0.17-1.53	0.08-0.55	0.03-0.20	0.02±
Soluble P mg/l	0.05-0.30	0.03-0.16	0.01-0.17	0.003-0.066
Organic N mg/l	0.28-2.88	0.22-1.93	0.12-1.58	0.25±
Ammonia N mg/l	2.60-4.36	0.36-2.42	0.02-1.90	0.00-0.39
Nitrate N mg/l	0.73-1.45	0.43-1.50	0.53-0.78	0.00-0.84
Chloride mg/l	83-294	32-90	24-56	19-46
Phenol μg/l	6-747	1-86	0-30	<1
Total Solids mg/l	403-936	219-585	162-374	159-218
Dissolved Solids mg/l	339-828	173-428	160-322	140-239
Conductivity μmhos/cm	620-1320	260-620	310-420	254-353
Coliforms/100 ml	9,000-1,000,000	1,400-58,000	300-33,000	<100

Table 5 gives a further brief breakdown on total coliforms for the river, harbor and dump.

TABLE 5

AVERAGE COLIFORM CONCENTRATIONS
(org/100 ml)

Date	River	Harbor	Dump
3/23-3/28/67	74,000	10,300	--
3/30-3/31/67	--	13,000	3,200
4/3-4/4/67	--	--	2,700
4/10-4/17/67	--	27,500	4,900

As stated previously, no correlation is apparent between coliform concentrations and dredging. For example in the dump area it appears that similar concentrations, due to river outflow and effluent from

Cleveland's Westerly Sewage Treatment Plant, would have occurred regardless of dredging. And, as stated previously, dumping in water farther from shore, probably would have shown some contamination.

MISCELLANEOUS MEASUREMENTS

Settleability tests have been made on river sediments. These tests were crude but showed several interesting things. For instance:

1. Sediments dumped into either distilled water or lake water disaggregate rapidly, the amount of disaggregation being directly related to water depth.

2. Flocculation is not possible in distilled water so that colloidal suspended sediment is noticeable indefinitely. Some flocculation, due to divalent cations occurs in lake water, settling is more rapid, but the top water will not clear for several days.

3. A long and indefinite period is required in quiet water for material to settle to the volume it originally occupied in the river.

4. Flocculation and settling occurs rapidly with the addition of alum. However the floc is light and probably easily transportable.

5. Chlorination in relatively large quantities (50 mg/l±) causes stabilization of most materials resulting in better settling but also creates a very offensive odor due to the formation of chlorophenols.

6. Mixing of sediment and water (simulating hopper dredging) increases settling time and compaction time due to solid break-up.

These rough lab tests have indicated the desirability of more precise tests which are presently being planned.

A bioassay of the effects of the addition of river sediment to lake water on algae and minnows has been done also in a rough fashion in the laboratory. This kind of work will continue and be refined, but the first indications are (1) that there is little if any effect on fish relative to direct toxicity and (2) after a few days a plankton bloom occurs in the sedimented tank but not in the control tank. The water was continuously aerated. It has also been found that with continuous aeration of river water, plankton blooms will occur and that the addition of river sediment will cause greater blooms. Plankton are scarce in the river however.

Another rough experiment was made to determine the effect of the most polluted sediment of the river on an established lawn. The first indications in this case are that the material is beneficial in areas where retention of moisture is desirable. It also has a slight fertilizing effect on grass and a much greater fertilizing effect on weeds. It might be quite useful as a soil conditioner. It was expected that the oil content might be harmful but this has not been indicated. After drying, oil is no longer apparent and it does not reappear when the sediment is rewetted.

TENTATIVE CONCLUSIONS

Although analyses on all samples have not yet been completed, and additional experiments appear necessary, some tentative conclusions can be drawn.

Immediate Effects of Dredging

River dredging - This dredging, except at the mouth of the river, is done under contract by clamshell and mud scows. It can be concluded that this is an effective and fairly efficient method of sediment removal which, in the Cuyahoga River, causes minimal disturbance in overlying water quality.

The disturbance of water quality is manifested mainly by a temporary increase in turbidity and the creation of additional oily scum and debris on the water surface, all in the immediate vicinity of the dredge. The additional material may be carried downstream during higher flows, but this has not been observed during the study.

Any change in chemical or microbiological water quality which might result from clamshell dredging is so relatively minor that it is completely masked by the high river background concentrations.

Lack of algae in the river water indicates lack of adequate light due to turbidity and that substances are present which at least inhibit growth. It is not likely that enough water is transported to the lake in this dredging to have any measurable effect on lake water quality. This is not true of sediments which also apparently contain some biological inhibitors, as indicated by scarcity of benthos even when the river water is oxygen-saturated.

When the Cuyahoga River becomes less polluted than at present, the immediate effects of dredging will be proportionately greater so that these conclusions will no longer be valid.

Microbiological effects could not be judged in the dumping ground water. Changes were in the range expected in the area without dumping. This perhaps is because of rapid dispersal and natural die-off of the organisms or perhaps because of materials' toxicity to bacteria.

Long-term Effects of Dredging

In the Cuyahoga River there are no known harmful lasting effects of dredging; instead there is beneficial reduction of noxious materials. In the outer harbor dredging may increase the ratio of organic to inorganic sediment, thus tending to maintain lower oxygen levels near the bottom and in the sediment.

The dumping ground bottom is oily sludge in an otherwise clay and gravel area. The bottom organisms are practically all sludgeworms. The oily sludge may contain substances toxic to bottom organisms. The sludge is spread over a wide area and the breakdown of substances is unknown.

Large quantities of nutrients, nitrogen and phosphorus, are added to the lake. Nitrogen compounds break down relatively easily reinforcing the supply of inorganic nitrogen for production of aquatic life. Phosphorus compounds, once they have become part of the sediments, are released very slowly except under certain conditions of pH and dissolved oxygen content of the overlying water. It must be considered however that phosphorus will become available for biological production, and that all phosphorus discharged to the lake has this potential. The rate of release will be directly proportional to the concentration in the sediments and the area over which it is spread. The rate will also be controlled by the chemistry of the overlying water, i.e. pH and dissolved oxygen content.

<u>Outer harbor dredging</u> - This dredging is done by hopper dredge which, of course, is vastly different from clamshell dredging. Efficiency of this method is determined almost entirely by slurry retention time in the dredge and settling time of disaggregated material. In general, higher content of in-place organic material results in lower efficiency of removal because much if not most of this material is discharged via the hopper overflow. This could lead to an increase

in the organic content of the sediment remaining after dredging.

The immediate effects in the outer harbor of hopper dredging upon water quality are an increase in suspended (mainly organic) solids content and a depression of dissolved oxygen levels. These effects do not extend any great distance beyond the dredge vicinity. Dissolved oxygen levels will drop, for example, from 90-100% saturation to 65-70%. More severe depression may occur but it was not found during this investigation. It is not likely however that levels are sufficiently depleted to have any significant adverse effect on biology.

Benthic populations in the harbor appear to decrease in the area of dredging. If this appearance is real, it is probably because of removal of the organisms rather than suppression.

Changes in chemical or microbiological character of the overlying water in the immediate vicinity of hopper dredging are minimal and are within the ranges expected without dredging.

<u>Dumping Ground Deposition</u> - The dumping of dredged material for the past year was divided into two small areas as shown on Figure 1, one area for outer harbor hopper dredging and the other for river dredging.

Other than an increase in suspended solids there were no significant immediate effects on the overlying water at the beginning of dredging. As time went on however it appeared that dumping of river sediment was reducing the oxygen content of the lower waters by as much as 20 percent.

Benthic organisms increased over most of the dumping ground just after the beginning of dumping, except at the site of river dumping. With continued river sediment dumping, the populations decreased, suggesting toxicity and lateral spread of the material. The spread is unknown but apparently went beyond the areal limits of the study.

The bottom sediments over most of the dumping ground are generally objectionable with a significant oil content. The condition became more severe as dumping progressed. This was expected. Considerable spreading over the bottom occurred and this was also expected.

It is apparent that spreading of the dumped materials can be rapid and a fair percentage is immediately removed in suspension from the area. Much of the material is immediately deposited but it then is subject to creep, flow, and re-suspension. Although it has not been investigated, it is possible that some of the dumped material from the present dumping area finds its way to shore, especially to the east of Cleveland.

Changes in chemical and bacterial water quality over the dumping ground are minimal except just above the bottom in the river dump area where significant increases in dissolved solids were sometimes shown during dredging.

Changes in water quality, attributable to dredging, have not been shown at any of the City of Cleveland's four water intakes.

The phosphorus content of Cuyahoga River sediments is high, on the order of 15 times the average content of land sediments which are not artificially enriched. It can also be assumed that these sediments will be distributed over a large area of the lake and the potential harm is great.

TENTATIVE RECOMMENDATIONS

Several interim recommendations can be made as a result of the investigation thus far. They are listed as follows:

1. The present Cleveland dumping ground should not be used in the future for the dumping of any dredged material.

2. River sediments should not be deposited anywhere in the lake; instead they should be confined and prevented from reaching the lake or the outer harbor.

3. Hopper-dredged outer harbor material should temporarily (until study is completed) be dumped in deep water about 10 miles from shore where bottom sediments are similar in some respects to those of outer harbor.

4. Hopper sediments should be discharged near the bottom - not into surface water - to lessen dispersion.

5. Hopper sediments should be discharged during colder months in unstratified water, to lessen possibility of prolonged sediment suspension on the thermocline.

6. Hopper dredging should include flocculation of incoming slurry if possible; chlorination could also be desirable.

Sediment dumped into a confined (diked) water area will likely require treatment. The most important treatment probably will be flocculation and chlorination. Filtration of effluent may not be critically necessary. Oil skimming may be required. Dumping into a slip and hydraulically transferring material from there into the diked area at Cleveland may cause serious degradation of outer harbor sediments unless escape of materials from the slip is prevented.

A final recommendation for disposal of outer harbor sediments may depend upon a limiting level of oil and grease in the sediments. Other measured constituents do not appear to be more harmful than those already existing in mid-lake sediments.

APPENDIX A5

SUMMARY OF FINDINGS
CLEVELAND DIKED DREDGING DISPOSAL AREA INVESTIGATION
1968

OCTOBER 1968

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION
CLEVELAND PROGRAM OFFICE

INTRODUCTION

Study Purpose

The Corps of Engineers and the Federal Water Pollution Control Administration are evaluating present dredging techniques and studying alternate procedures for the disposal of polluted harbor dredgings with the ultimate objective of providing leadership in the nationwide effort to improve water quality through prevention, control, and abatement of water pollution by Federal water resources projects. For the long-range permanent plan a pilot program of experimentation has been initiated to investigate all alternate disposal and treatment methods, and evaluate pollution abatement results.

Eight localities were selected as pilot study areas: (1) Green Bay Harbor, Wisconsin, (2) Calumet Harbor, Illinois and Indiana, (3) Indiana Harbor, Indiana, (4) Detroit, Michigan, (5) Toledo, Ohio, (6) Cleveland, Ohio, (7) Buffalo Harbor, New York, and (8) Great Sodus Bay, New York. Study areas were selected on the basis of the pollution level of the dredged sediments and availability of alternate disposal sites.

This report presents data and findings resulting from the Cleveland Pilot dike study. It includes an evaluation of the disposal and treatment methods employed, and an evaluation of the pollution abatement results.

Cleveland was selected as a pilot study area because of the high pollution level of the dredged sediments from the Cuyahoga River, convenience for field experimentation, and availability of an alternate disposal site. The study plan included the disposal of a portion of the Cuyahoga River dredgings from the Spring 1968 dredging operation into a diked disposal area located in the Cleveland east outer harbor. Two methods of disposal were to be used: (1) pump directly from scows into the diked area, and (2) pump the material from the slip into the diked area. The study would also include an evaluation of the performance of an air barrier constructed across the opening of the slip and treatment of the diked supernatant in a portable water treatment plant.

DESCRIPTION OF AREA

Greater Cleveland Harbor consists of an outer harbor and the lower part of the Cuyahoga River (Figure 1). The outer harbor, sheltered by breakwaters, is about 5 miles long and 500 to 1,500 feet wide. The Cuyahoga River navigation channel, nearly six miles long, averages about 200 feet in width.

Cleveland Harbor requires more volume of maintenance dredging than any other harbor on the Great Lakes. The Corps of Engineers reports some 15 million cubic yards of material removed from the Cleveland Harbor during the past ten years, more than half of which was removed from the river portion. The outer harbor is dredged hydraulically by Corps dredges while the river is clamshell dredged under contract.

The lower Cuyahoga River and navigation channel throughout the Cleveland area is, in effect, an open sewer. The river is choked with debris, oils, scums, floating globs of organic sludges, and dissolved solids. Foul-smelling gases rise from decomposing organic materials on the river's bottom. The river has a chocolate-brown or rust color.

The inadequately treated wastes from the Cleveland Southerly Sewage

Treatment Plant, and an undetermined number of combined sewer overflows discharge huge quantities of oxygen-demanding wastes, nutrients and bacterial contamination to the river. These domestic wastes are joined by the discharges from the major industrial complex in the Cleveland area. The industrial discharges include large quantities of solids, metals, oil, sulfates, ammonia, acids, and other materials.

The outer harbor area receives the discharges from the Cuyahoga River and numerous storm water and combined sewer overflows. The water quality varies with meteorological conditions especially the wind which frequently allows lake water to enter the harbor. Due to density differences, lake water frequently underruns or overruns the water of the outer harbor and lower reaches of the Cuyahoga River.

Two lake disposal sites were established to hold the disposal of dredgings from the Cuyahoga River and outer harbor. One disposal site, unused since 1957, is located nine miles due north of the Cleveland West Pier Head Light. The disposal site is two miles long by one mile wide. The lake disposal site presently in use is located along the lake side of and parallel to the east breakwater (Figure 1). It is three-quarters of a mile wide and two and one-half miles long. An area 1,500 feet square located in the western portion of this disposal site is used for disposal of dredgings from the outer harbor. A second area approximately one thousand feet square located in the eastern portion of the same disposal site is used for disposal of Cuyahoga River dredgings.

The Cleveland pilot study called for construction of a diked disposal area (completed in December 1967) in the eastern outer harbor area,

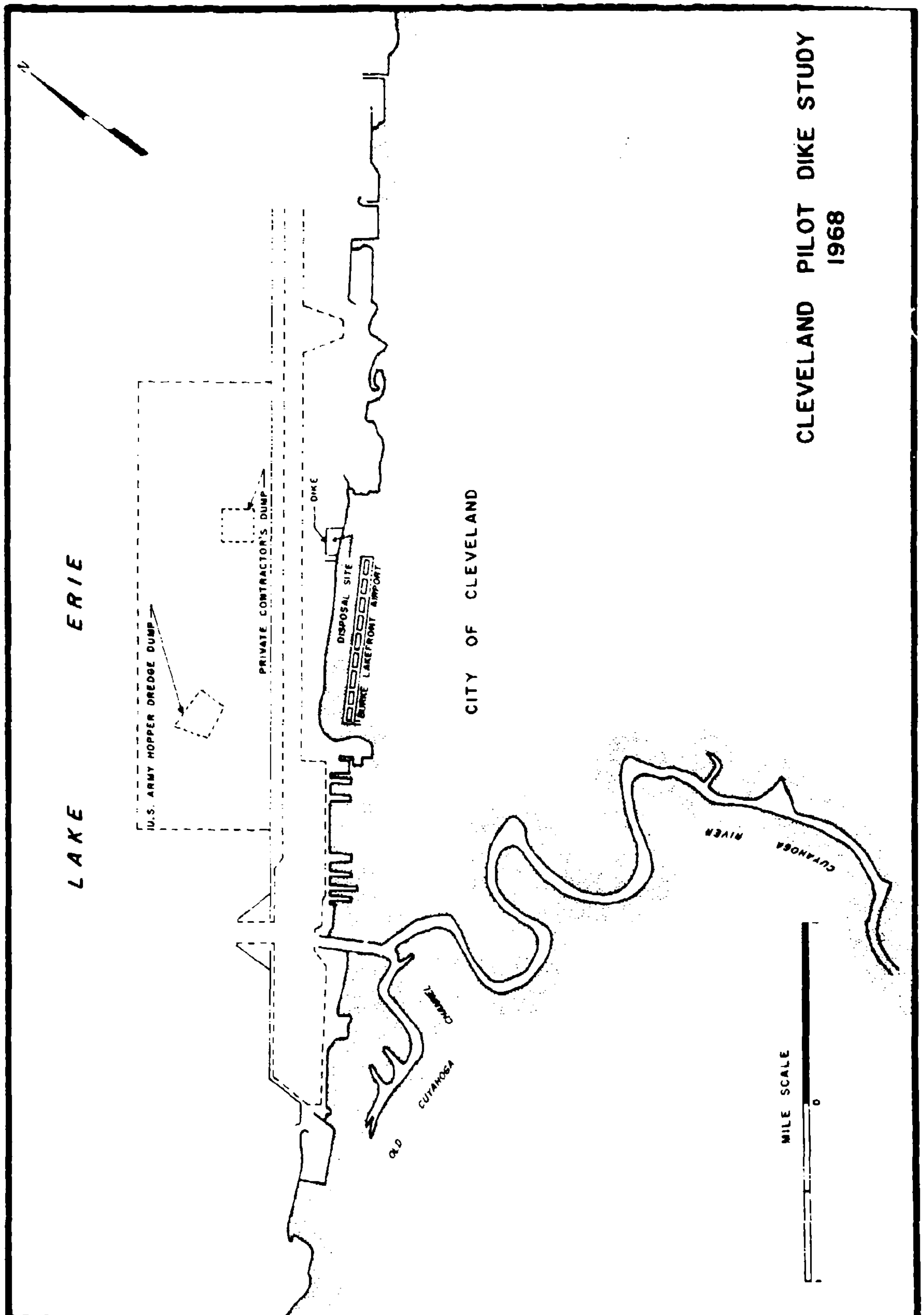

CLEVELAND PILOT DIKE STUDY
1968
N
LAKE ERIE
U.S. ARMY HOPPER DREDGE DUMP
PRIVATE CONTRACTOR'S DUMP
DIKE
DISPOSAL SITE
BURKE LAKEFRONT AIRPORT
CITY OF CLEVELAND
CUYAHOGA RIVER
OLD CUYAHOGA CHANNEL
MILE SCALE
0

FIGURE 1

(Figure 1). A slip was constructed parallel to the west side of the dike to accommodate dredging equipment and transfer of dredged materials.

The location of the dike is exposed to Cuyahoga River discharges, numerous storm water and combined sewer overflows, and lake water, depending on metereological conditions. Three of the numerous combined sewer overflows are in close proximity to the diked area (Figure 2). The overflows are connected to the Easterly Interceptor sewer. The 33rd Street sewer discharges directly into the south end of the dike slip. The proximity of numerous waste discharges and the variable water quality in the harbor make the site unfavorable as a study area.

The dike (Figures 2 and 3), constructed from 286,000 tons of limestone and dolomite, was designed to act as a filter. The dike core and filter bed were constructed from Type B and Type C limestone. The exterior riprap was constructed from Type A dolomite. The void space for the Type A stone is estimated as 25 percent and for the Type B and C stone is 30 percent, (Corps of Engineers).

Dimensions and other pertinent data concerning the dike and adjacent slip include:

<u>Dike</u>		
Length	880 ft.	
Width (west end)	430 ft.	
(east end)	500 ft.	
<u>Diked Area</u> (before dumping)		
Average water depth	24 ft.	
Surface area	387,000 ft.^{2}	43,000 yd.^{2}
Bottom area	277,000 ft.^{2}	31,000 yd.^{2}
Water volume	7,920,000 ft.^{3}	293,000 yd.^{3}
Total volume to top of dike	10,050,000 ft.^{3}	372,000 yd.^{3}
<u>Slip</u>		
Length	420 ft.	
Width	220 ft.	
Volume	1,673,000 ft.^{3}	62,000 yd.^{3}

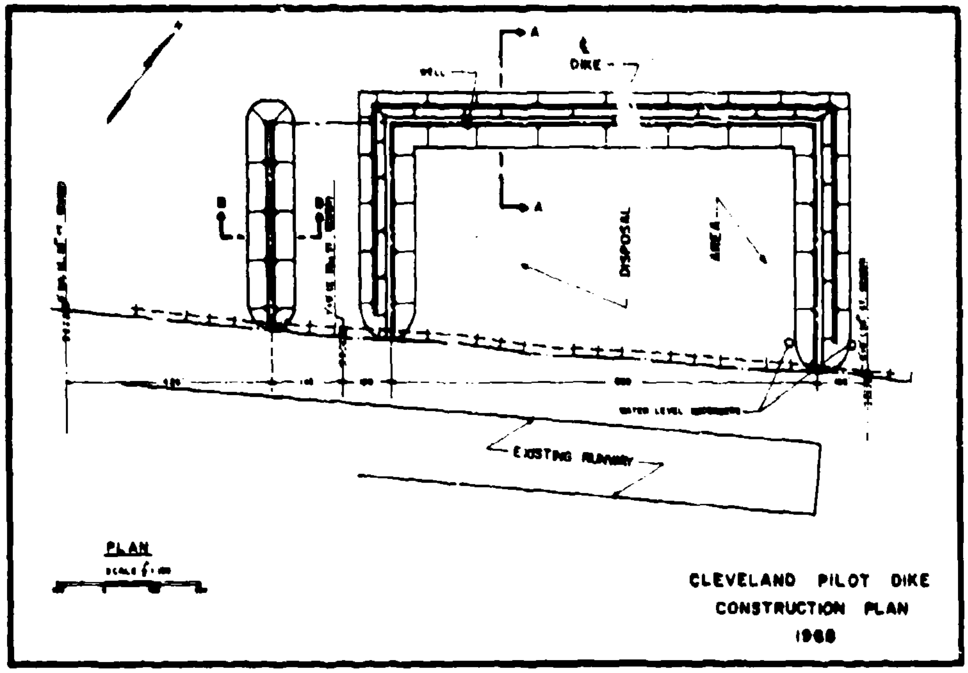


FIGURE 2

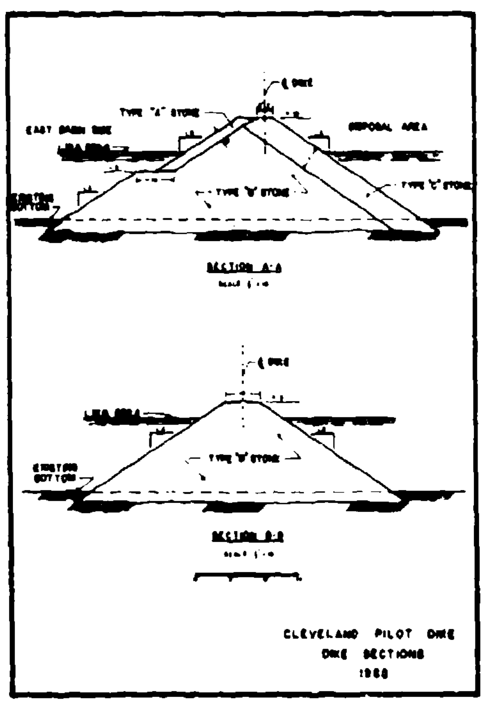


FIGURE 3

All calculations are referred to a lake elevation of 571 feet above International Great Lakes datum.

To assist sampling, a well was constructed in the dike about 130 feet northeast of the northwest corner. The well was constructed from a perforated steel pipe extending to the bottom of the dike, having an inside diameter of 21 inches.

Water level recorders were installed inside and outside the southeast corner of the dike.

STUDY METHODS

The sampling schedule was designed around dredging and pumping schedules (Table 1). The first method of disposal into the diked area began May 1, 1968 and continued until June 12, 1968. The second method of disposal began June 21, 1968 and continued through August 1, 1968.

Analytical field and laboratory methods are given in the "Laboratory Manual, Cleveland Program Office" except for special methods which are described in this report.

Scow samples were obtained by compositing five one-quart grab samples from each of eight scow compartments prior to dumping. Grab samples were taken at various depths in each compartment with a specially constructed sampling device. This cylindrical sampler, attached to a long pole, has a mechanical tripping mechanism to obtain a mud sample from any depth in the scow.

The dredge influent dilution water samples were obtained by compositing half-gallon grab samples at half-hour intervals during pumping. The samples were taken at a depth of five feet below the surface of the slip

TABLE I

CLEVELAND PILOT DIKE STUDY
1968 SAMPLING SCHEDULE

Date	Water in Dike	Water Outside Dike	Water in Well	Portable Water Plant	Dredge Influent Water	Slip Effluent	Dredge Effluent	In Place Sediment	Scow Sediment
4/9								F.L	
4/10	F.[1]L[2]							F.L	
4/22									F.L
5/1	Commenced First Method of Disposal								
5/1	F	F							F.L
5/2	F	F	F				F		
5/8	F.L	F.L			F.L				F.L
5/13	F.L	F.L			F.L				F.L
5/20	F.L	F.L			F.L				F.L
5/23	F.L	F,L	F.L						
5/28	F.L	F	F		F.L				F.L
6/5	F.L	F			F.L				F.L
6/12	Completed First Method of Disposal								
6/14								F.L	
6/15	Two scow loads dumped into slip for base								
6/17	Two scow loads dumped into slip for base								
6/17						F			
6/18	F.L			F.L					
6/19	F								
6/21	Commenced Second Method of Disposal								
6/24				F.L					
6/25		F				F			
6/26	F						F.L		
6/28						F			
7/1	Aerial Photographs taken					F.L			

TABLE 1 (Concluded)

CLEVELAND PILOT DIKE STUDY
1968 SAMPLING SCHEDULE

Date	Water in Dike	Water Outside Dike	Water in Well	Portable Water Plant	Dredge Influent Water	Slip Effluent	Dredge Effluent	In Place Sediment	Scow Sediment
7/3						F			
7/9				F.L					
7/10	F								
7/10	Air Barrier Activated								
7/29				F.L					
7/31	F.L								
8/1	Completed Second Method of Disposal								
8/15								F.L	
8/21	F.L								
8/29	F.L	F.L							

[1]F - denotes samples taken for in-field determinations

[2]L - denotes samples taken for laboratory determinations

at the inlet pipe to the pump.

Water in the diked area was sampled at five locations (C22-41, A, B, C, D, and E) just prior to pumping (Figure 4). Field measurements for temperature, dissolved oxygen, pH, conductivity, and transparency were made at each of the five locations. Laboratory determinations were performed on surface and bottom samples composited from the five locations. Bottom sediment samples were taken outside the dike at several locations (Figures 4 and 5) before dumping, between dumping phases, and after all dumping was completed. These samples, for chemical and biological analyses, were taken with a Peterson dredge. In addition many water samples were taken outside the dike.

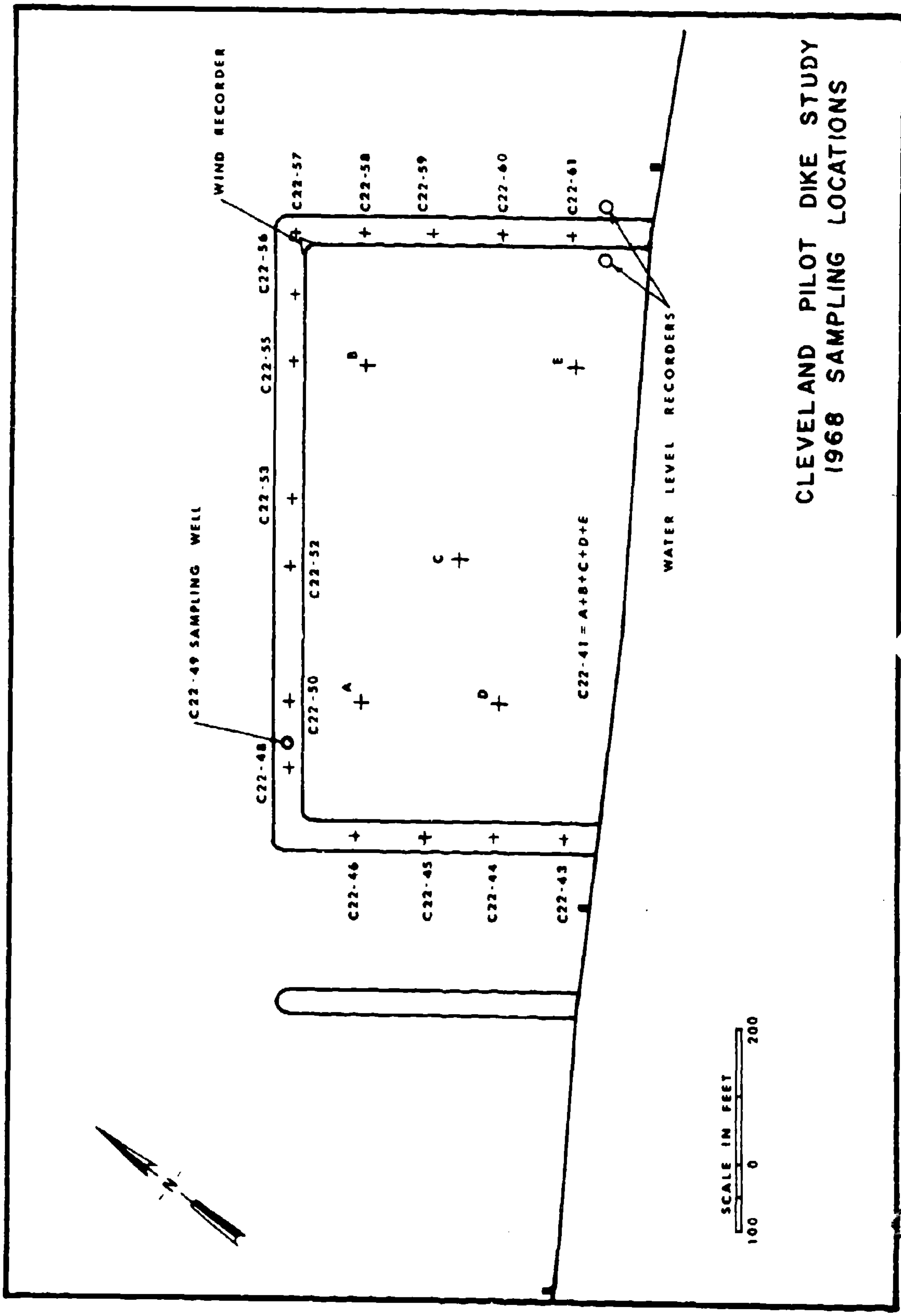
METHODS OF DISPOSAL

Dredging Method

Maintenance dredging of the Cuyahoga River is routinely performed under contract to the Corps of Engineers. Due to extensive sedimentation, two contracts are awarded annually, one in the spring and one in the fall. A total of 524,965 cubic yards (scow measure) were dredged from the Cuyahoga River under the Spring 1968 contract.

River channel sediment was removed with a clamshell type dredge. A total of 88 workdays (107 calendar days) were required to dredge the specified quantity of material. The dredge operated round-the-clock when conditions permitted.

The clamshell dredge placed the dredged material into scows for transport to the disposal site. The scows, having bottom dump capabilities, have a maximum capacity of about 1,300 cubic yards. The scows were towed



CLEVELAND PILOT DIKE STUDY
1968 SAMPLING LOCATIONS
WIND RECORDER
WATER LEVEL RECORDERS
C22-49 SAMPLING WELL
C22-41 = A+B+C+D+E
C22-43
C22-44
C22-45
C22-46
C22-48
C22-50
C22-52
C22-53
C22-55
C22-56
C22-57
C22-58
C22-59
C22-60
C22-61
A
B
C
D
E
N
SCALE IN FEET
100
0
200

FIGURE 4

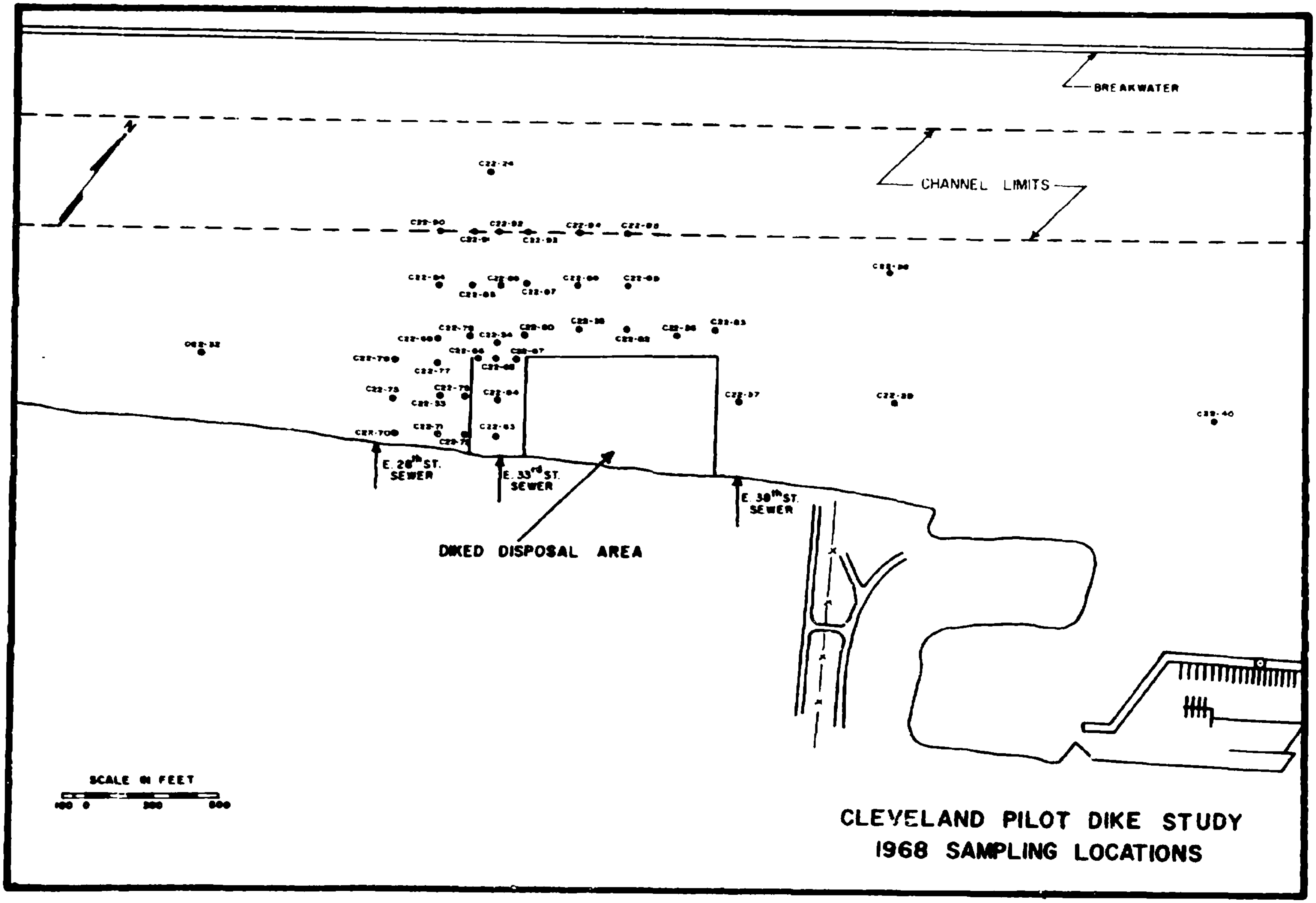

BREAKWATER
CHANNEL LIMITS
N
DIKED DISPOSAL AREA
E. 26th ST. SEWER
E. 33rd ST. SEWER
E. 38th ST. SEWER
SCALE IN FEET
CLEVELAND PILOT DIKE STUDY
1968 SAMPLING LOCATIONS

FIGURE 5

to the disposal sites in pairs by tug at the rate of one pair per work shift. However, river traffic and weather were controlling factors. A total of 422 scows were loaded during the course of the contract.

A total of 90,647 cubic yards were disposed in the diked area, while the balance of the dredgings, 434,318 cubic yards, were disposed by conventional methods in the open-lake disposal area adjacent to the breakwall.

DISPOSAL PUMPING

The pilot program specifies two methods for placing dredgings into the diked area: (1) pump the dredgings from the scows directly into the diked area, and (2) pump the dredgings from the slip into the diked area.

Method 1

To pump dredgings directly from the scows into the diked area, the contractor moved on site a dredge equipped with a special suction head. The dredge was secured in the slip along the west side of the dike. A discharge pipe, laid over the dike and supported on pontoons, extended to near the center of the diked area. The scows were moored in the slip to pilings adjacent to the dredge. The suction head was constructed to simultaneously jet slip water into the scow and pump the diluted material from the scows. The suction head could be lowered or raised to different elevations in the scow. Pumping was intermittent due to debris and sediment clogging the pump. The dredge effluent was observed to vary in consistency from slip water to that of the scow sediment.

One scow load was pumped into the diked area each day. The volume varied from 200 to 1,311 cubic yards (scow measure) (Table 2). A total of 45,555 cubic yards were placed in the diked area by this method. Daily pumping times varied from 15 minutes to 4 hours and 15 minutes.

TABLE 2

CLEVELAND PILOT DIKE STUDY
METHOD I
QUANTITIES DEPOSITED IN DIKED AREA AND PUMPING TIMES
1968

Date	Quantities Deposited cu.yds.(scow measure)	Pumping Time Hrs.	Min.
May 1	1,311	2	30
2	1,248	2	45
3	400	1	00
4	841	1	30
5	1,289	4	00
6	1,285	4	15
7	1,216	2	00
8	1,242	1	35
9	1,187	4	15
10	1,234	3	00
11	1,204	1	15
12	1,238	1	15
13	200	0	15
14	400	1	00
15	0	0	00
16	1,005	4	00
17	772	2	15
18	1,121	3	00
19	1,144	2	15
20	1,101	2	30
21	1,123	1	30
22	1,239	2	10
23	1,212	2	05
24	1,225	2	10
25	1,239	1	45
26	1,278	1	50
27	1,255	1	50
28	1,170	1	30
29	1,204	1	45
30	0	0	00
31	1,278	1	45
June 1	1,148	2	40
2	1,190	1	40
3	1,052	1	45
4	1,223	1	45
5	1,100	2	20
6	971	1	45
7	1,170	2	00
8	1,245	1	50

TABLE 2 (Concluded)

CLEVELAND PILOT DIKE STUDY
METHOD I
QUANTITIES DEPOSITED IN DIKED AREA AND PUMPING TIMES
1968

Date		Quantities Deposited cu.yds.(scow measure)	Pumping Time Hrs.	Pumping Time Min.
June 9		1,125	1	50
10		1,253	1	40
11		1,245	1	55
12		1,203	2	00
	Total	45,555		

The dredgings required dilution with slip water to permit pumping. It was initially estimated that the dilution would be in the ratio of 2 parts water to 1 part sediment. The flow varied for both the influent water and the dredge effluent. No continuous flow measurements were obtained. Based on recently obtained percent solids and pump data, (Corps of Engineers) the average ratio of water to sediment is estimated at 5 to 1. The total volume (sediment and dilution water) pumped into the diked area during the first method of disposal was estimated as 273,000 cubic yards.

Method 2

The second method of disposal into the diked area consisted of bottom dumping the scow sediment into the south end of the slip. Using a hydraulic dredge equipped with a rotating cutting head, the sediment was then pumped from the bottom of the slip into the diked area. The method of discharge to the diked area was the same as that used in Method 1 except for a baffle plate on the end of the discharge pipe. To prevent removal of the natural slip sediment, four scow loads of scow sediment were dumped into the south end of the slip to serve as a base. Subsequently, two scow loads were dumped every other day on top of the base. The material was dredged from the slip at the rate of approximately one scow load per day. A total of 45,092 cubic yards (scow measure) were disposed using this method. The total input (sediment and water) to the diked area is estimated as 496,000 cubic yards using a ratio of 10 parts water to 1 part sediment (Corps of Engineers). Daily quantities deposited into the diked area varied from 997 cubic yards to 1,347 cubic yards (Table 3). Pumping times varied from 2 hours 15 minutes to 7 hours 20 minutes.

TABLE 3

CLEVELAND PILOT DIKE STUDY
METHOD 2
QUANTITIES DEPOSITED IN DIKED AREA AND PUMPING TIMES
1968

Date	[1]Quantities Deposited cu.yds.(scow measure)	Pumping Time Hrs.	Min.
June 21	1,347	3	05
22	1,292	2	45
23	1,321	3	00
24	1,137	3	00
25	1,313	3	00
26	1,147	4	00
27	1,204	3	25
28	1,292	2	15
29	1,313	3	55
30	1,104	2	20
July 1	1,307	3	00
2	1,281	3	10
3	1,215	2	50
4	0	0	00
5	1,292	3	05
6	1,136	3	00
7	0	0	00
8	997	2	25
9	1,200	3	00
10	1,302	3	00
11	1,162	3	15
12	1,296	3	00
13	1,237	3	10
14	0	0	00
15	1,172	3	00
16	1,161	3	00
17	1,292	3	00
18	1,292	3	00
19	1,270	3	00
20	1,270	3	55
21	1,292	3	00
22	1,137	3	00
23	1,178	3	00
24	1,141	3	00
25	1,193	3	00
26	1,150	3	35
27	1,205	3	30
28	1,226	2	30
29	1,098	3	00

Table 3 (Concluded)

CLEVELAND PILOT DIKE STUDY
METHOD 2
QUANTITIES DEPOSITED IN DIKED AREA AND PUMPING TIMES
1968

Date	[1]Quantities Deposited cu.yds.(scow measure)	Pumping Time Hrs.	Pumping Time Min.
July 30	1,121	7	20
31	Clean up	5	00
August 1	Clean up	2	50
Total	45,093		

[1] Yardage shown are from individual scows credited to each day's pumping and are not the exact yardage pumped each day.

The study plan included the installation of equipment to form an air barrier across the open-ended slip to prevent the escape of sediment dumped into the slip. The air barrier was created by air bubbles released from 61 perforated, weighted air lines laid across the bottom of the outer 150 feet of the slip. The study plan called for disposal into the slip for the first two weeks without the air barrier in operation. During the second two weeks the air barrier would be operated continuously at half capacity and during the last two weeks the air barrier would be operated continuously at full capacity. However, due to problems in design, installation, or operation, the air barrier did not perform as planned. An air curtain was not created, thus there was no effect on the containment of material.

DESCRIPTION OF DIKE INFLUENT

The sediment transported to the diked area was very similar to the river sediments as analyzed in 1967. Table 4 is a summary comparison of the 1967 river sediment sample data and scow samples taken during this study.

Since water from the dike slip was used as pump dilution water for all the sediment placed within the dike, its constituents must also be counted in the load to the diked area. Table 5 lists a summary of the analyses of the slip water and compares them to averages in the outer harbor and to the diked water prior to dumping.

Total loads of various constituents to the diked disposal area are summarized in Table 6 along with dike effluent loads and percent retention. Loads are based upon the reported sediment volume of 90,647 cubic

TABLE 4

COMPARISON OF 1967 RIVER SEDIMENT SAMPLING
AND 1968 SCOW SEDIMENT SAMPLING

Parameter	1967 River Sediment mg/g	1968 Scow Sediment mg/g
Chlorine Demand	32	33
Chemical Oxygen Demand	240	196
Total Solids	490	480
Volatile Solids	125	133
Oil and Grease	35	36
Total Phosphorus	4.0	3.9
Kjeldahl Nitrogen		3.2
Total Iron	110	139
Lead	--	0.46
Nickel	--	0.09
Chromium	--	0.24
Cadmium	--	0.02
Cobalt	--	0.19

TABLE 5

COMPARISON OF HARBOR, SCOW SLIP, AND DIKED WATER
BACKGROUND DATA
(mg/l except as noted)

	Outer Harbor 1967	Scow Slip 1968	Dike Water 1968
Chlorine Demand	--	15	--
Suspended Solids	41	38	2
Volatile Suspended Solids	--	21	0
Total Phosphorus	0.17	0.09	0.05
Kjeldahl Nitrogen	1.90	2.02	1.23
Lead	--	0.058	--
Nickel	--	0.090	--
Chromium	--	0.034	--
Cadmium	--	0.010	--
Cobalt	--	0.025	--
Phenols	0.010	0.003	0.005
Total Coliforms/100 ml	17,000	5,800	150
Fecal Coliforms/100 ml		1,500	2
Standard Plate Count 35°/ml		29,000	310

TABLE 6

LOADS TO DIKED AREA
Tons

	Scow Sediment	Dredge Dilution Water	Total Load to Dike	Dike Effluent	Dike % Retention
Total Solids	54,000	174	54,500	255	99.6
Total Suspended Solids	*	22		62	99.9
Volatile Suspended Solids	*	12		17	
Total Volatile Solids	7,200	*	7,200		99.8
Chlorine Demand (15 min)	1,750	88		6	99.7
Chemical Oxygen Demand	10,500	*	10,500	--	
Total Phosphorus	215	0.016	215	0.5	99.8
Total Kjeldahl Nitrogen	175	1.15	176	12	93.2
Oil and Grease	2,000	*	2,000		
Phenols	*	0.001		0.005	
Total Iron	7,500	*	7,500		
Lead	25	0.01		0.08	99.7
Nickel	50	0.05		0.05	99.9
Chromium	13	0.02		0.05	99.6
Cadmium	11	0.005		0.005	99.9
Cobalt	1	0.01		0.007	99.3

* analysis not made

yards plus influent pumping water volume of 679,000 cubic yards.

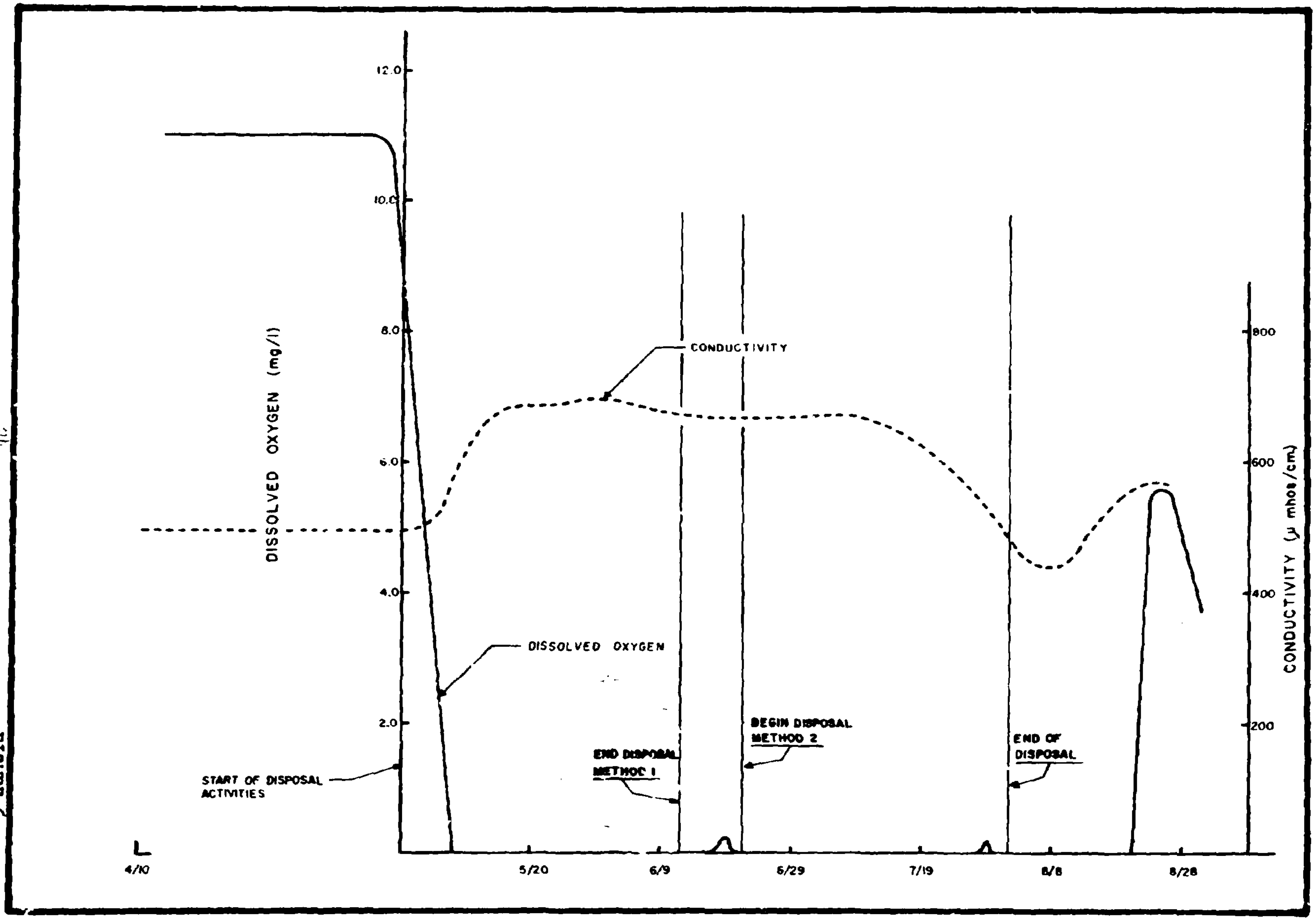
DESCRIPTION OF DIKE EFFLUENT

TOP WATER

The dike effluent shall be considered equivalent in quality to the top water (supernatant) in the diked area during both methods of disposal. It was not possible to obtain a representative sample of the dike effluent because of its slow seepage through the dike and immediate dilution with harbor water. Calculated effluent loads of various constituents are shown in Table 6.

Prior to the first method of disposal, the supernatant was high in dissolved oxygen averaging 92 percent of saturation at 11.0 mg/liter. The conductivity, which measures ionic species in solution and consequently is indicative of inorganic dissolved solids, was 490 micromhos per cm. During the first day of disposal the dissolved oxygen reserve in the dike was dep. ·ed 10 percent. After the second day of disposal, 25 percent of the background DO was depleted. Disposal occurred daily for the following week with no further monitoring of the dike supernatant. Upon remonitoring, one week after the start of disposal, measurements revealed a complete depletion of the supernatant dissolved oxygen. The bottom waters lost oxygen at an even faster rate. During the first week conductivity measurements increased from 490 to 690 μmhos/cm, (Figure 6).

A small amount of DO was measured in the supernatant (0.3 mg/l) one week after cessation of the first method and three days prior to initiation of the second method. Conductivity measurements decreased slightly



DISSOLVED OXYGEN (mg/l)
12.0
10.0
8.0
6.0
4.0
2.0
CONDUCTIVITY (μ mhos/cm)
800
600
400
200
CONDUCTIVITY
DISSOLVED OXYGEN
START OF DISPOSAL ACTIVITIES
END DISPOSAL METHOD 1
BEGIN DISPOSAL METHOD 2
END OF DISPOSAL
4/10
5/20
6/9
6/29
7/19
8/8
8/28

FIGURE 6

during this period indicating dilution and/or some chemical reaction and settling. With the start of the second method and until completion, the conductivity increased only slightly not quite reaching the peak of the first method. During the second method the oxygen remained depleted in the supernatant with only a slight rise in DO on the last day, prior to completion.

As can be seen from Table 7, there was a huge increase in nutrients and solids with the start of dike disposal. The nutrient increases remained fairly stable throughout the study period although solids-wise large decreases toward background values were noted between methods and toward the end of the second method.

Three weeks after the study period, dissolved oxygen in the supernatant had reached 5.6 mg/l and conductivity measurements decreased toward normal (Fig. 6). The oxygen replenishment of the supernatant coincided with and resulted from huge population increases of green coccoid algae mostly *Ankistrodesmus sp.* and an unidentified nanno-plankton. Prior to disposal the supernatant transparency was as much as 5 ft. At no time during the test, through both methods, did the transparency exceed 3 inches.

Dike Filtration

The dike effluent flow is a function of the rate of disposal inputs, the permeability of the dike, and the ambient lake level fluctuations. As measured, lake level fluctuations of two or three tenths of a foot were common with occasional instances of one foot or more. Diked water levels closely coincided with lake level fluctuations except when peak levels occurred. Approximately 43,000 cubic yards of water passed through

TABLE 7

CLEVELAND PILOT DIKE STUDY
SUMMARY OF DIKED WATER CHEMISTRY AND MICROBIOLOGICAL DATA

Parameter	Before Disposal	During Method 1	[1]Between Methods	During Method 2	[1]After Disposal
% Sat	92	0	2	0	38
CON		618	642	647	541
pH	6.8	7.5	6.9	7.4	7.4
TP	0.05	0.89			
TK-N	1.23	21.8	27.2	17.1	7.1
TSS	2	121	36	83	46
VSS	0	30.8	4	25.5	28.5
P	4.7	14.3	3.1	5.2	1.7
Cl D		11.5	1.3		4.4
Pb		0.161	0.087	0.113	
Ni		0.084	0.044	0.073	
Cr		0.110	0.036	0.052	
Cd		0.012	0.001	0.006	
Co		0.015	0.008	0.009	
[2]TC	150	5,650	350	1,100	450
[2]Fe	2	950	102	540	10
[2]SPC-35	310	662,500	115,000	98,000	2,500

[1] Data based on one sampling

[2] Median count were possible

the dike with a one-foot change in diked water level.

No head was measurably created in the diked area during either disposal method, therefore the rate of input was essentially equal to the rate of discharge from the diked area. Exclusive of water level induced displacements, a total volume of 273,000 cubic yards passed through the dike during the first method of disposal and 496,000 cubic yards during the second method.

The dike effectively retains all floating debris. Oils might eventually filter through the dike, especially in the form of emulsions or soaps, the latter resulting from reaction with the natural lye content of the original diked water. Most dissolved solids are expected to pass through the dike, at least after the first electrical and chemical reactions have taken place. The limestone and dolomite dike will electrically adsorb and chemically interact with the negatively charged colloids and anions in solution to effect their deposition and subsequent removal. Coating of the dike through filtration, in addition to electrical and chemical deposition, will eventually cover the reactive limestone and dolomite surfaces to the point where dissolved solids would pass through unaffected in character. Winds from the north will backwash the dike with harbor water, in effect partially renewing the reactive filter surfaces, at least for a short period.

In an effort to characterize the dike effluent, a well was constructed in a northern portion of the dike (see Figure 2). After initial displacement of the original water by pumping, the well was sampled on several occasions. In general the concentrations of the parameters measured were between the lower harbor and the higher diked water values. Total suspended solids inside the well (29 mg/l) were approximately the same as found in the harbor water. From the limited solids data available it is indicated that the suspended solids (non-colloidal) are being effectively retained by the dike.

WATER PLANT EVALUATION

In the event that the supernatant should need further treatment to meet water quality standards, the efficiency of a portable water treatment plant was evaluated. Four procedures for water treatment were employed, the last three being a variation of the normal, standard treatment for potable water. These procedures included (1) coagulation, filtration, and disinfection, (2) coagulation only, (3) coagulation and filtration, and (4) filtration only. The water plant was modular in construction being composed of a combination mixing, sedimentation basin, and diatomaceous earth pressure filters. Ferric chloride was used as coagulant, lime for pH control, and calcium hypochlorite as disinfectant.

As can be seen from Table 8, for the removal of turbidity, chemical oxygen demand and nutrients, the standard treatment (coagulation, filtration, and disinfection) for producing a potable water was the most effective. As modifications from the standard procedure (elimination of acknowledged essential steps in water treatment) were made for the sake of economics, treatment efficiency suffered. In addition, the expected operational difficulties materialized - shortened filter runs, excessive chlorine demand etc. With respect to dissolved metals, no procedure was significantly effective. In this instance anionic polyelectrolyte coagulant aids most likely would have increased metals removal substantially.

Microbiological removals were greatest with the standard procedure.

TABLE 8

PORTABLE WATER TREATMENT PLANT RAW AND FINISHED WATER
CHEMISTRY AND BACTERIOLOGICAL DATA
1968
(mg/l)

Date	Type Sample	DO	CON µmhos/cm	Cl R	Turb	COD	TK-N	TP	Pb	Ni	Cr	Cd	Co	TC /100 ml	FC /100 ml	SPC-35 /ml
Method I																
6/18	Raw		660													
	Raw		660		45	70	34	1.14	0.26	0.10	0.13	0.01	0.01	8,000	100	100,000
	Raw		670													
	Raw		660													
	Fin.		790	3.0												
	Fin.		760	5.0	0.9	27	21	0.02	0.01	0.03	0.02	0.00	0.02	<2	<2	<1
	Fin.		710	5.0												
	Fin.		700	3.5												
6/24	Raw	0	595		650	143	23	5.08	0.35	0.12	0.17	0.01	0.04	800	430	Spreader
	Raw	0	595													
	Fin.	6.3	650		0.9	18	20	0.01	0.03	0.05	0.03	0.01	0.00	<10	<5	28
	Fin.	6 6	650													
7/9	Raw	0	850		80	52	24	0.50	0.62	0.13	0.09	0.02	0.01	1,200	1,100	690,000
	Fin.	6.6	900	1.5	0.8	12	20	0.05	0.01	0.06	0.01	0.00	0.01	<5	<5	6
7/29	Raw	0	570													
	Raw	0	690		120	40	17		0.10	0.08	0.04	0.01	0.01	2,300	150	24,000
	Raw	0	700													
	Fin.	6.5	650													
	Fin.	6.5	650	4.0	0.7	18	16		0.01	0.06	0.00	0.01	0.00	<2	<2	3
	Fin.	6.5	650													

TABLE 8 (Continued)

PORTABLE WATER TREATMENT PLANT RAW AND FINISHED WATER
CHEMISTRY AND BACTERIOLOGICAL DATA
1968
(mg/l)

Date	Type Sample	DO	CON µmhos/cm	Cl R	Turb	COD	TK-N	TP	Pb	Ni	Cr	Cd	Co	TC /100 ml	FC /100 ml	SPC-35 /ml
Method 2																
6/19	Raw	0.1	670		35	45	25	0.42	0.02	0.12	0.04	0.01	0.01	1,000	40	58,000
	Raw	0.2	680													
	Fin.	6.6	750		2	21	22	0.06	0.01	0.04	0.05	0.00	0.00	30	<5	500
	Fin.	2.6	760													
7/9	Raw	0	850		80	52	21	0.50	0.03	0.10	0.09	0.01	0.00	1,200	1,100	650,000
	Fin.	6.6	900		3	14	20	0.03	0.00	0.06	0.02	0.00	0.01	<5	<5	30
7/29	Raw	0	590													
	Raw	0	590		60									2,500	200	7,000
	Raw	0	590													
	Fin.	6.5	640													
	Fin.	6.5	640		14	25	16		0.03	0.04	0.00	0.01	0.00	<5	<5	12
	Fin.	6.5	640													
Method 3																
6/19	Raw	0.1	670		35	45	25	0.42						1,000	40	58,000
	Raw	0.2	680													
	Fin.	6.0	790		0.6	18	24	0.02	0.01	0.03	0.00	0.00	0.01	<10	<5	4
	Fin.	5.9	780													
7/29	Raw	0	595													
	Raw	0	595		100									1,900	150	5,300
	Raw	0	600													

TABLE 8 (Concluded)

PORTABLE WATER TREATMENT PLANT RAW AND FINISHED WATER
CHEMISTRY AND BACTERIOLOGICAL DATA
1968
(mg/l)

Date	Type Sample	DO	CON µmhos/cm	Cl R	Turb	COD	TK-N	TP	Pb	Ni	Cr	Cd	Co	TC /100 ml	FC /100 ml	SPC-35 /ml
Method 3 (cont'd)																
7/29	Fin.	6.5	690													
	Fin.	6.5	690		0.8	19	17		0.00	0.04	0.00	0.00	0.01	14	<2	6
	Fin.	6.5	690													
Method 4																
6/19	Raw	0.2	660		45	52	23	0.42	0.02	0.10	0.04	0.01	0.01	900	70	64,000
	Raw	0	660													
	Fin.	3.2	660		15	36	25	0.19	0.01	0.03	0.01	0.00	0.02	410	70	1,800
	Fin.	2.6	655													
6/24	Raw	0	595		90	76	24	0.50	0.27	0.11	0.15	0.01	0.01	400	310	360,000
	Raw	0	595													
	Fin.	2.7	600		15	27	19	0.12	0.01	0.05	0.03	0.01	0.00	160	30	>2,100
	Fin.	2.7	600													
7/29	Raw	0	590													
	Raw	0	590		90	59	17		0.10	0.05	0.06	0.01	0.01	2,600	300	51,000
	Raw	0	595													
	Fin.	2.5	600		50	29	17		0.04	0.06	0.01	0.00	0.02	1,100	120	21,000

Proper coagulation and sedimentation are most effective in removing turbidity and bacteria. Polishing by filtration and disinfection produce a bacteriologically safe water treatment plant effluent.

CHANGES IN OUTER HARBOR DUE TO DIKED EFFLUENT

WATER QUALITY CHARACTERISTICS

The harbor water in the dike vicinity normally varies between the extremes of Cuyahoga River water and Lake Erie background, depending upon river flow and wind velocity and direction. It is likely that water flow through the harbor, although reversing direction frequently, is several orders of magnitude greater than dike effluent flow. With this kind of situation, it was futile to attempt to determine dike effluent-induced changes in harbor water. However it can be reasonably concluded that the effect was very slight, except for an occasional narrow discolored band along the dike proper.

Although dike effluent effects were relatively unimportant, changes did occur in adjacent harbor waters as a result of slip effluent during the second method of disposal, that of dumping sediment into the slip and pumping it therefrom.

Figure 7 illustrates patterns of turbidity on three occasions during the second method of disposal. These patterns were caused primarily by churning of the slip water by the scow tug which also forced the turbid water out into the harbor, where it was carried by wind and currents.

Field measurements during the second method of disposal revealed patterns of conductivity (Figures 8 through 11) and dissolved oxygen

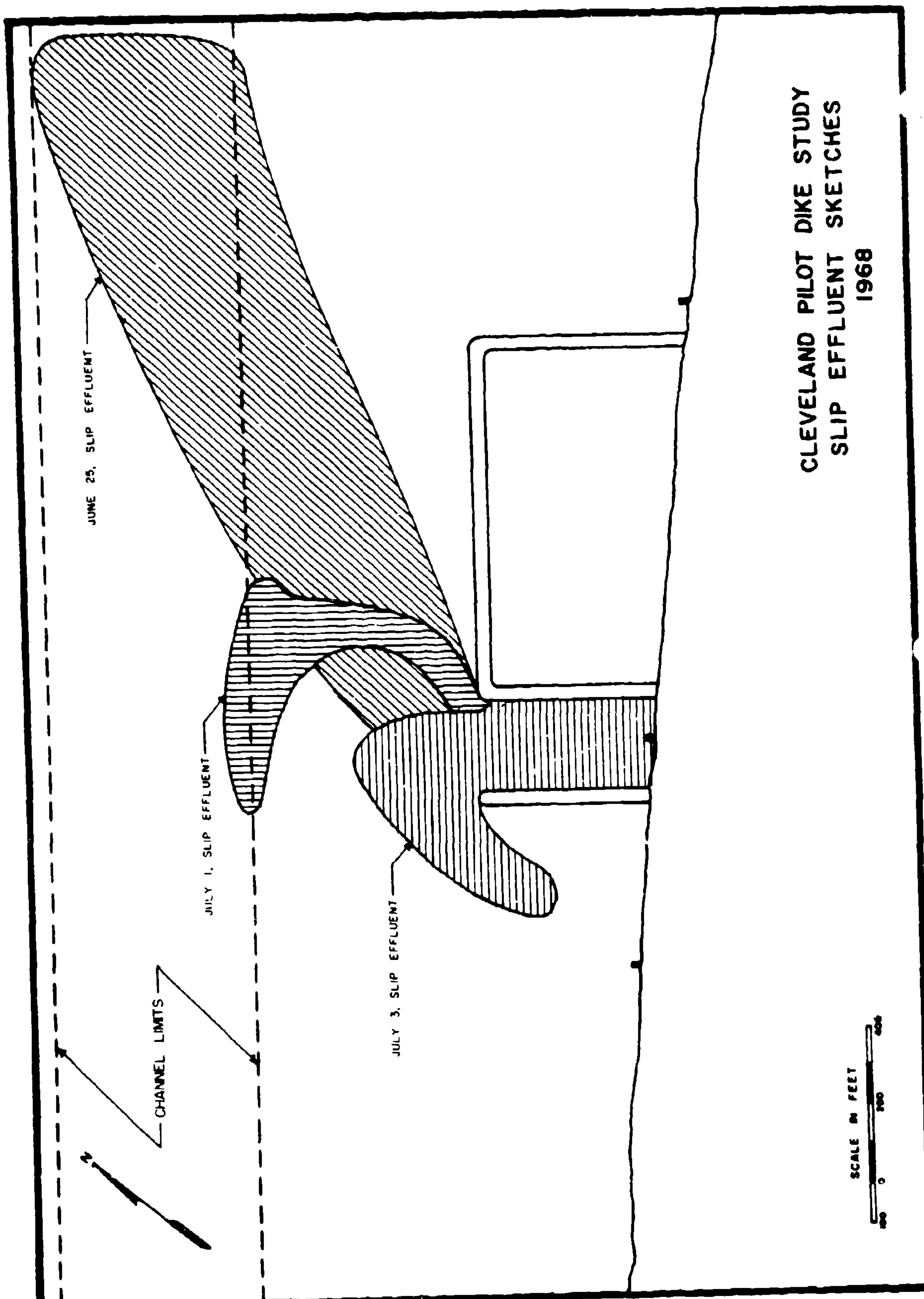

CLEVELAND PILOT DIKE STUDY
SLIP EFFLUENT SKETCHES
1968
JUNE 25, SLIP EFFLUENT
JULY 1, SLIP EFFLUENT
JULY 3, SLIP EFFLUENT
CHANNEL LIMITS
SCALE IN FEET
N

FIGURE 7

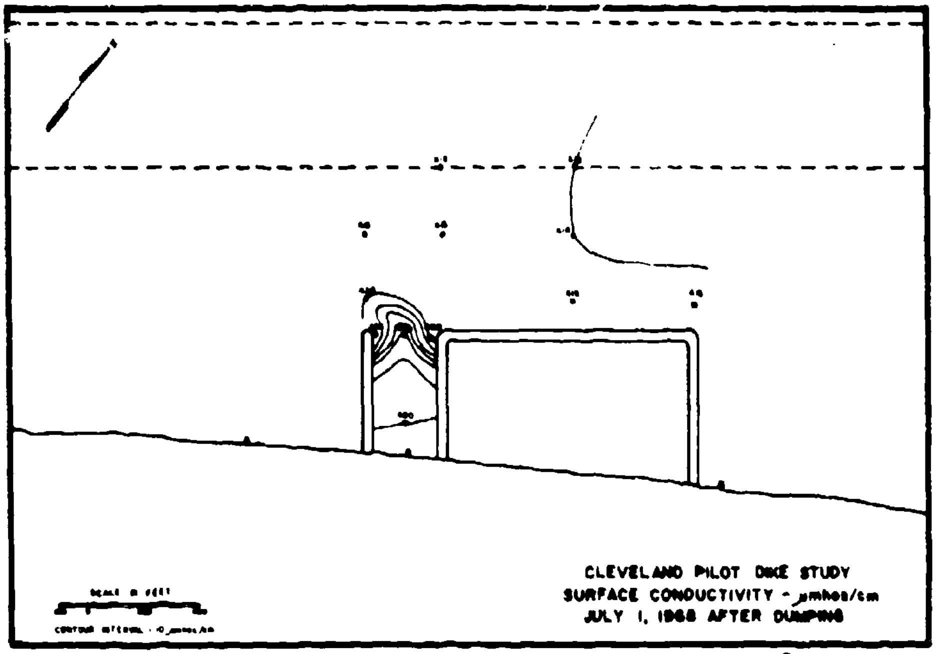


FIGURE 8

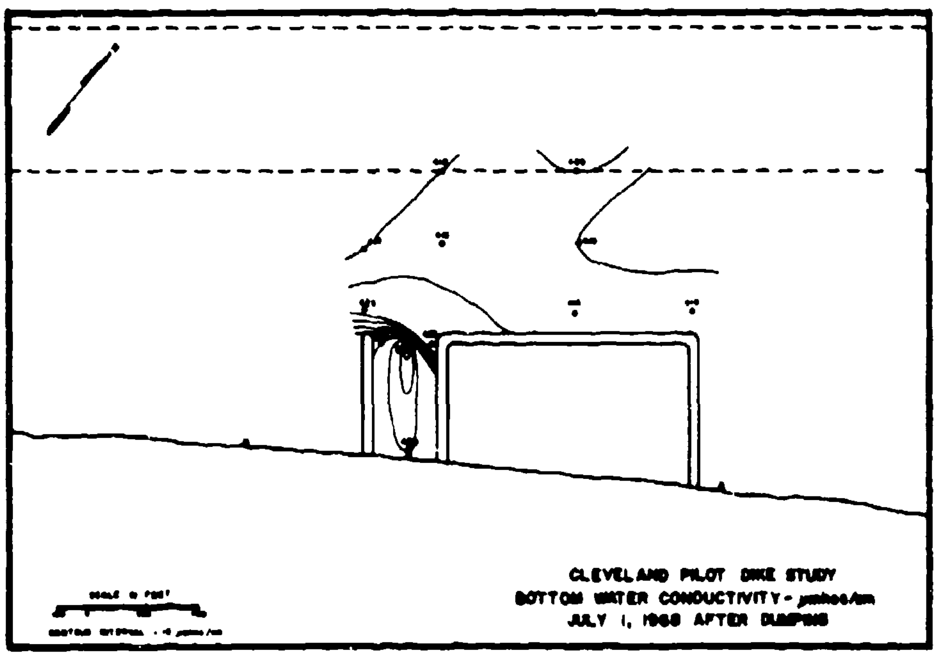


FIGURE 9

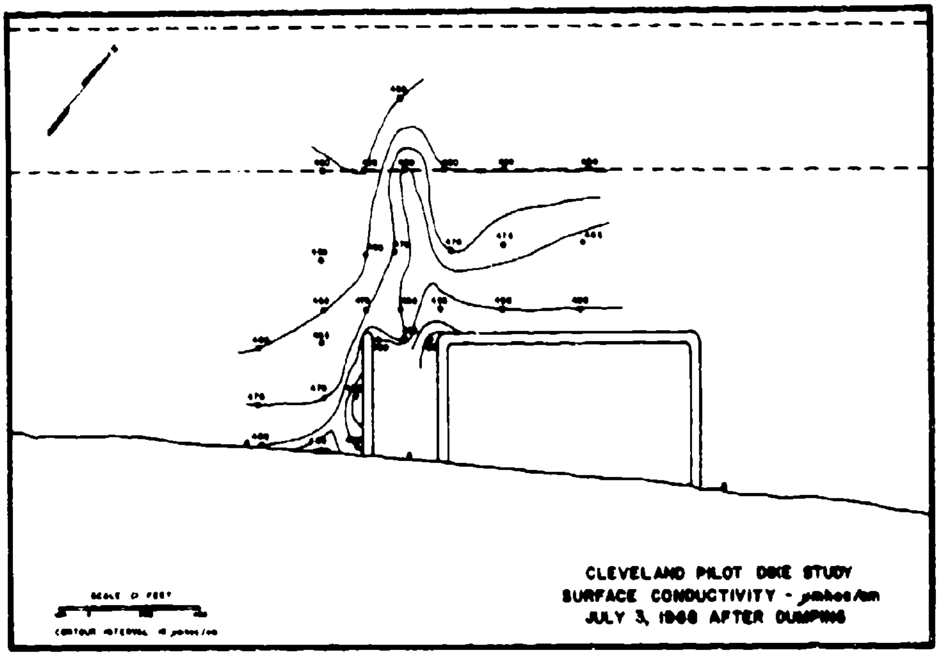


FIGURE 10

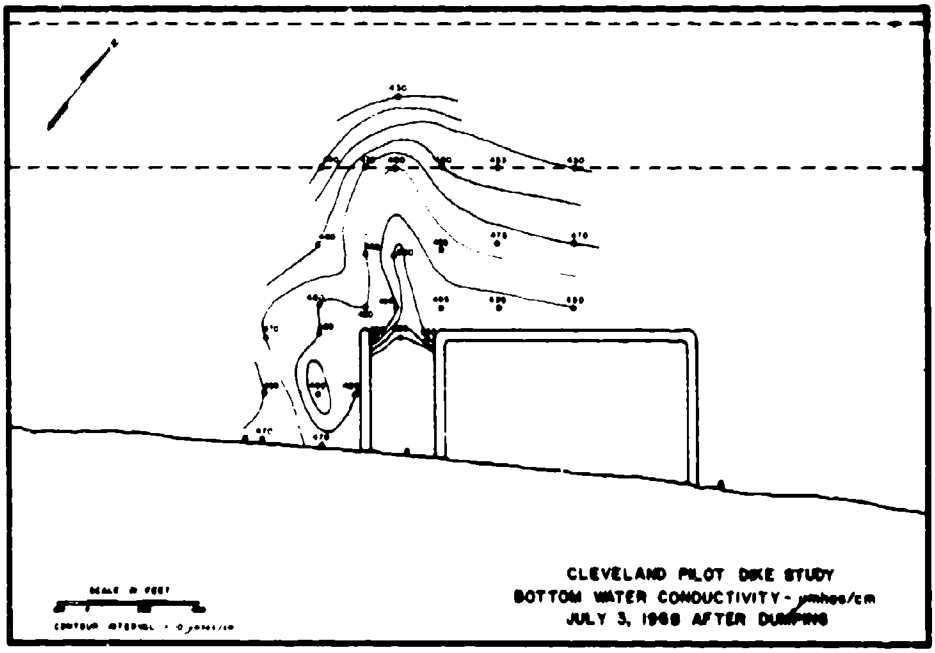


FIGURE 11

(Figures 12 through 15) which strikingly illustrate the effects of slip effluent. During the first method of disposal, (pumping directly from scows) no patterns were traceable to the slip.

SEDIMENT CHARACTERISTICS

The harbor sediments in the vicinity of the dike were analyzed chemically and biologically before disposal, between the two methods of disposal, and after disposal was completed. Although sampling for biology appeared adequate, sediment chemistry sampling left much to be desired. Chemistry sampling was done with a Peterson dredge which penetrated several inches into the soft sediments. Deposition throughout the disposal period was probably much less than that depth and the portion attributable to disposal effluent was likely only a small fraction of that deposition. Thus chemistry sampling of sediment would show measurable changes due to disposal effluent only where deposition of disposed materials was greatest, in and very near the scow slip.

The above factors must be kept in mind when examining the sediment chemistry as portrayed in Figures 16 through 35.

Figures 16, 17, and 18, show changes in chemical oxygen demand. The changes are not significant except at the mouth of the slip and in the harbor channel. Changes in the harbor channel may not be related to diked disposal. Figures 19, 20, and 21, show total iron. It remained essentially the same except for a significant increase at the slip mouth during the second method of disposal.

Figures 22, 23, and 24, total kjeldahl nitrogen, indicate that changes are probably controlled to a greater degree by factors other than disposal, since values were relatively uniform throughout the study. However

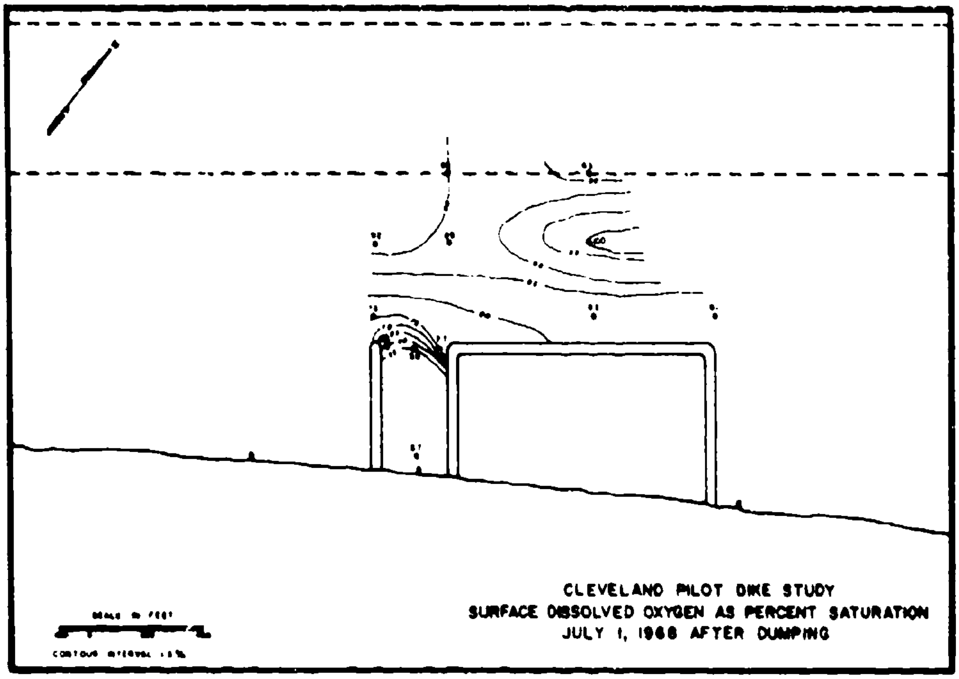


FIGURE 12

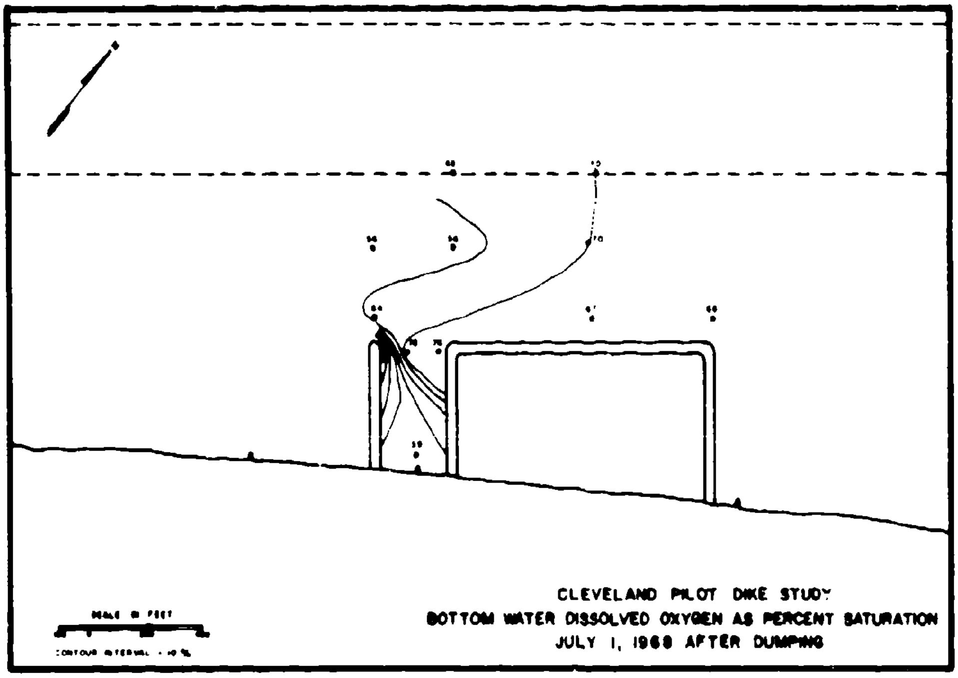


FIGURE 13

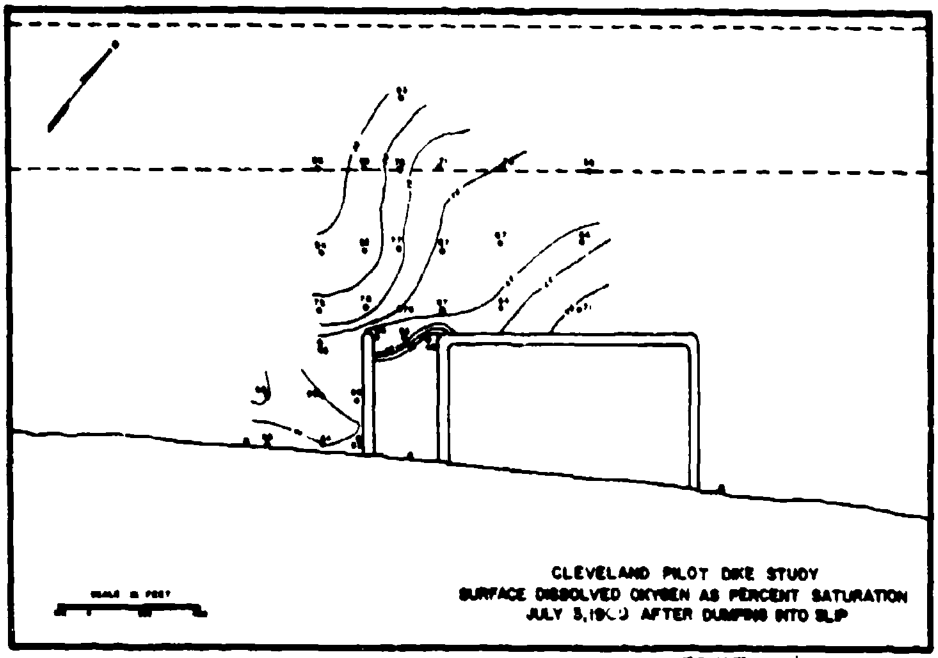


FIGURE 14

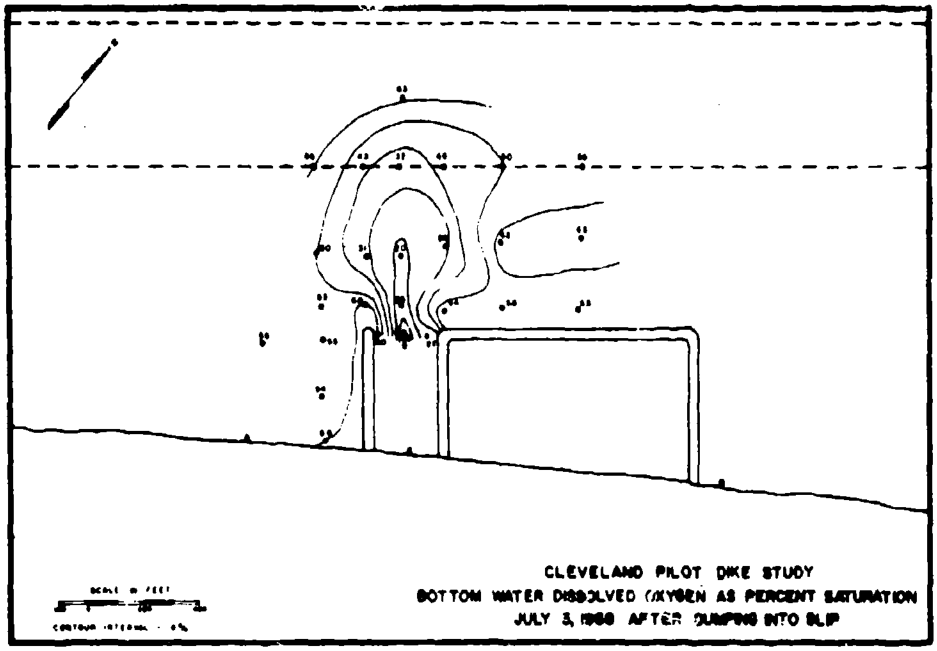


FIGURE 15

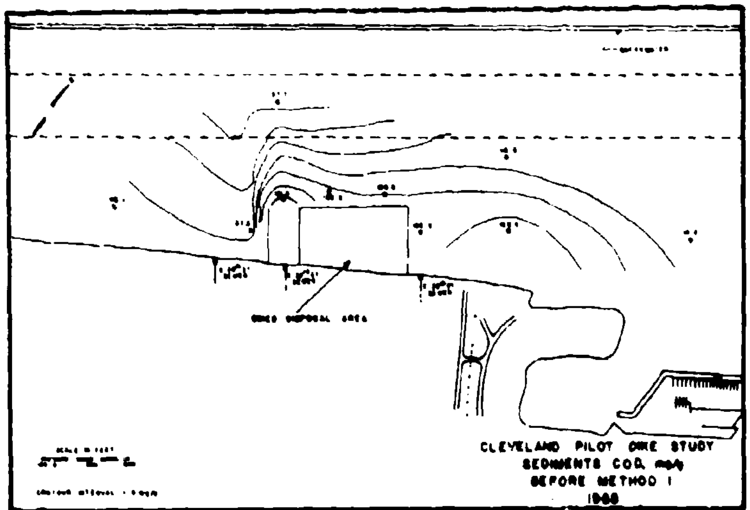


FIGURE 16

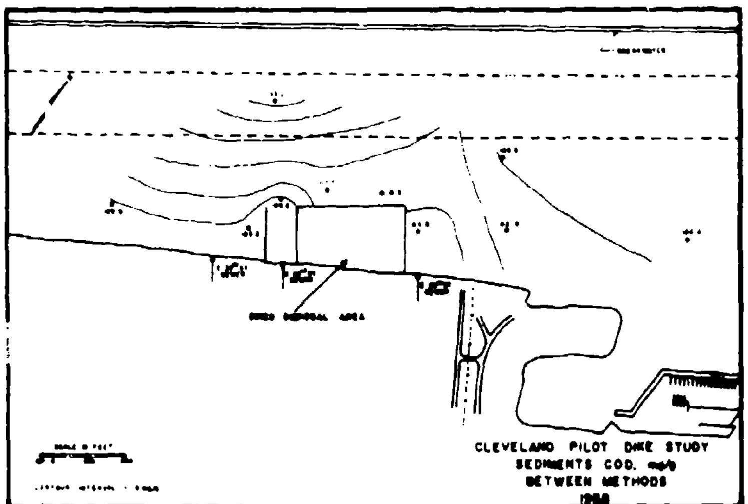


FIGURE 17

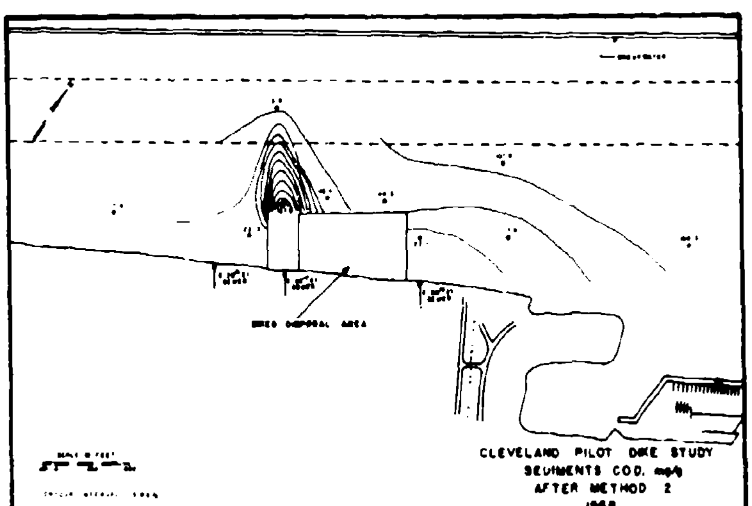


FIGURE 18

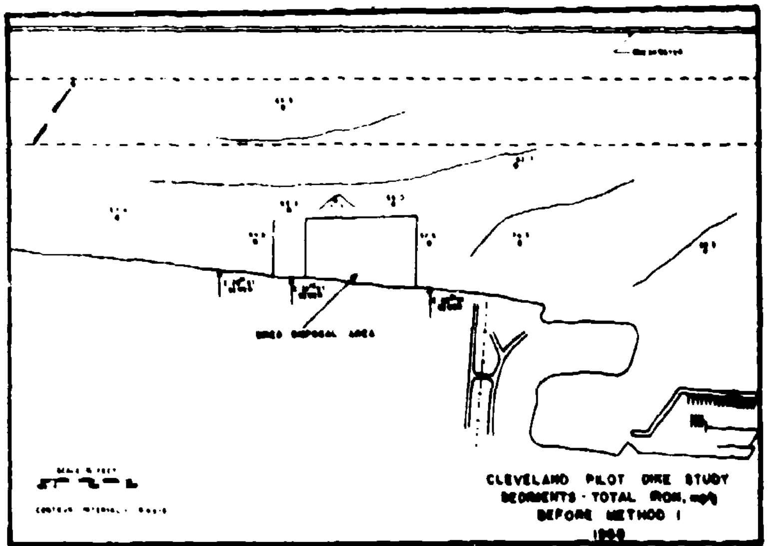


FIGURE 19

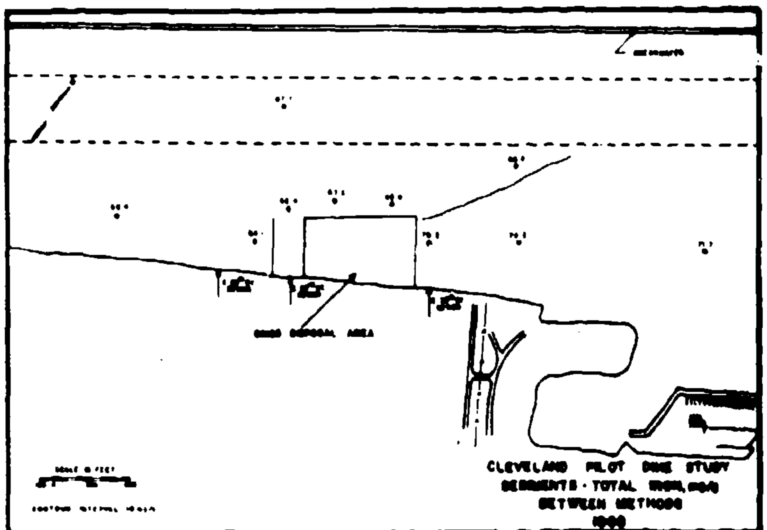


FIGURE 20

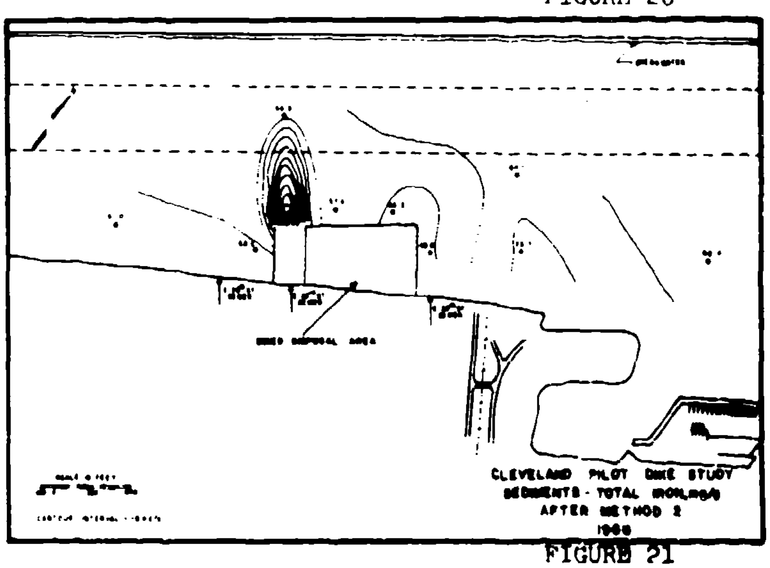


FIGURE 21

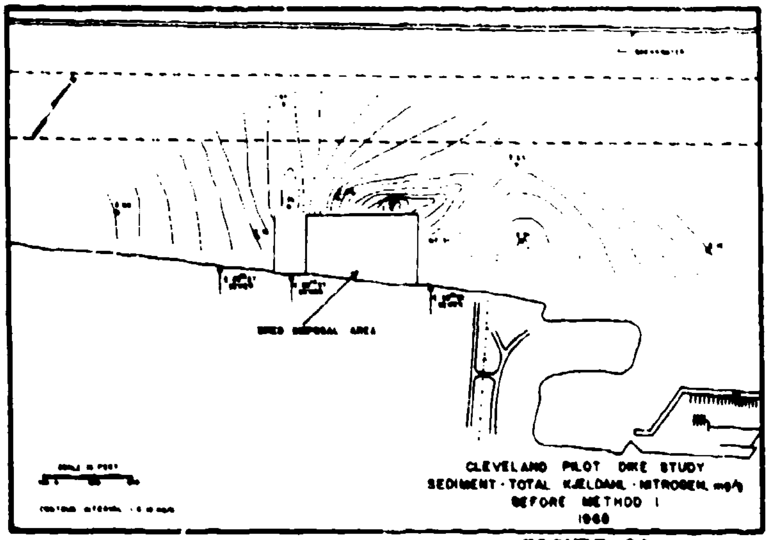


FIGURE 22

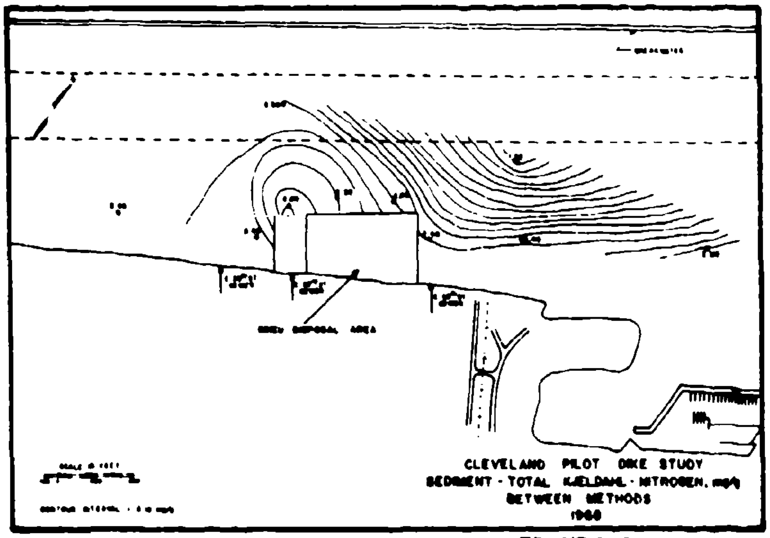


FIGURE 23

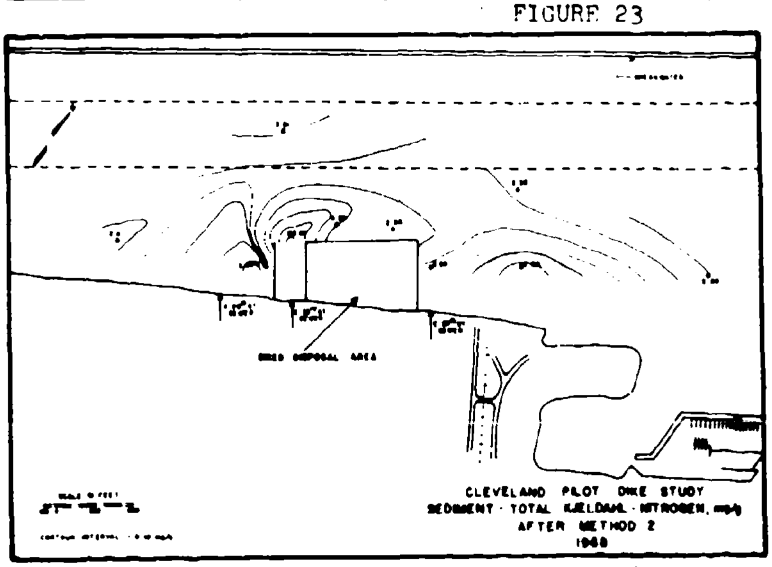


FIGURE 24

phosphorus exhibited rather dramatic changes (Figures 25, 26, and 27). In general phosphorus increased during the first method of disposal and, except near the slip mouth, declined during the second method. These changes indicate that phosphorus sedimentation phenomena from other causes overshadow the effects of disposal effluent, except very near the scow slip where phosphorus concentrations raised to and remained at higher levels during disposal.

Oil and grease concentrations in the harbor sediments (Figures 28, 29, and 30) in the vicinity of the dike showed redistribution during disposal but not a significant increase except near the slip entrance and then only during the second method of disposal.

Volatile sediment solids (Figures 31, 32, and 33) decreased during the first method of disposal and then, during the second method, increased markedly near the dike. Chlorine demand (Figures 34 and 35), not measured before disposal, increased moderately during the second method of disposal.

The benthic fauna of Cleveland outer harbor are dominated by Oligochaeta and Sphaeriidae with lesser numbers of Chironomidae, Prosobranchia, and Hirudinea. Figures 36, 38, and 40 depict the Oligochaeta (sludgeworm) populations before disposal, between disposal methods, and after disposal. Figures 37, 39, and 41 show Sphaeriidae (fingernail clams) populations at the same times.

Sludgeworms in the harbor in the vicinity of dike before disposal and between disposal methods showed rather wide areal variation in population with the highest at the slip entrance, possibly in response to the sewer discharge into the slip. During the second method the total

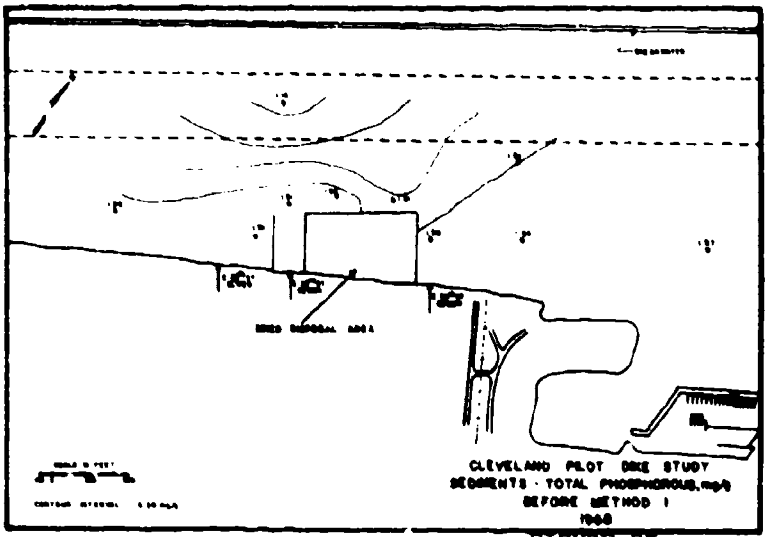
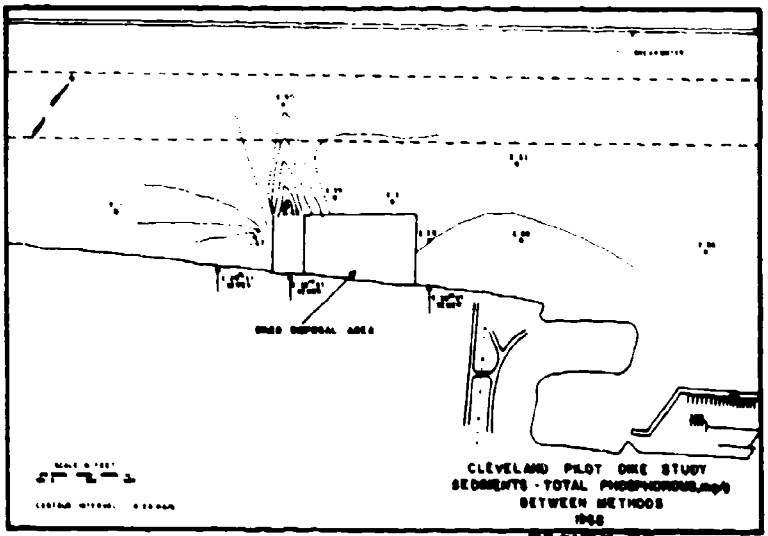


FIGURE 25



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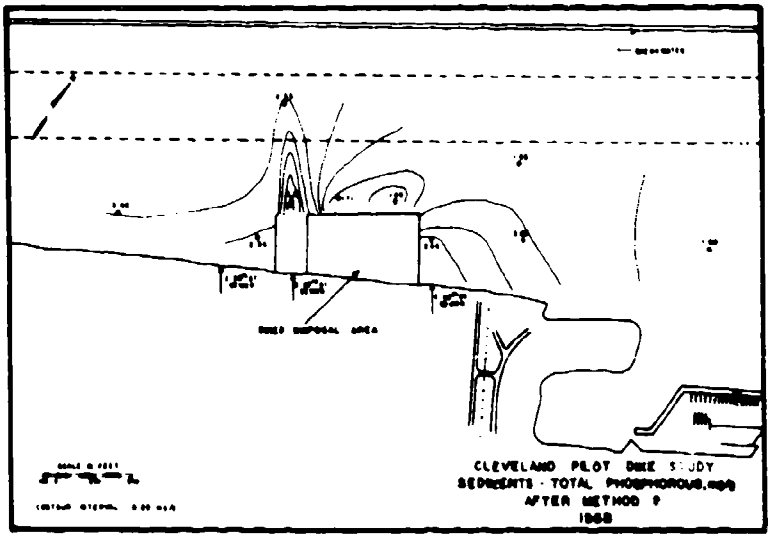

FIGURE 27

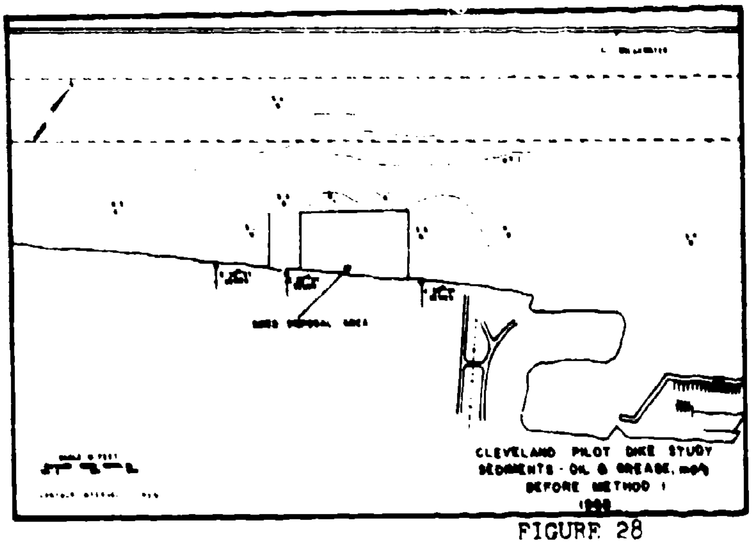

FIGURE 28

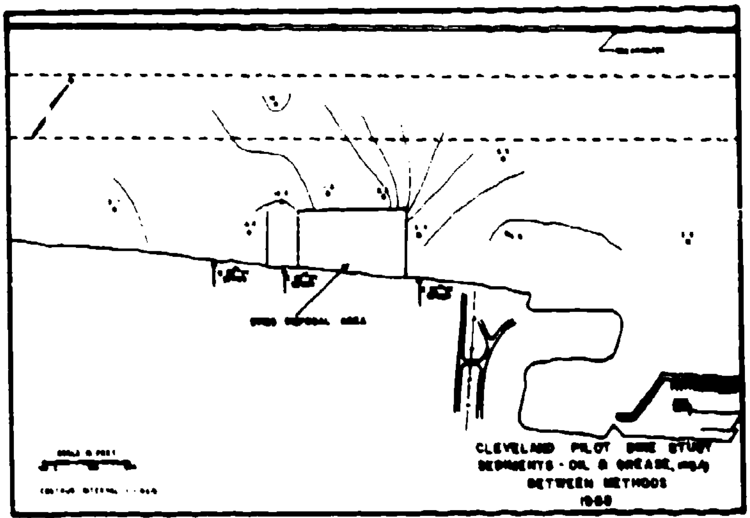

FIGURE 29

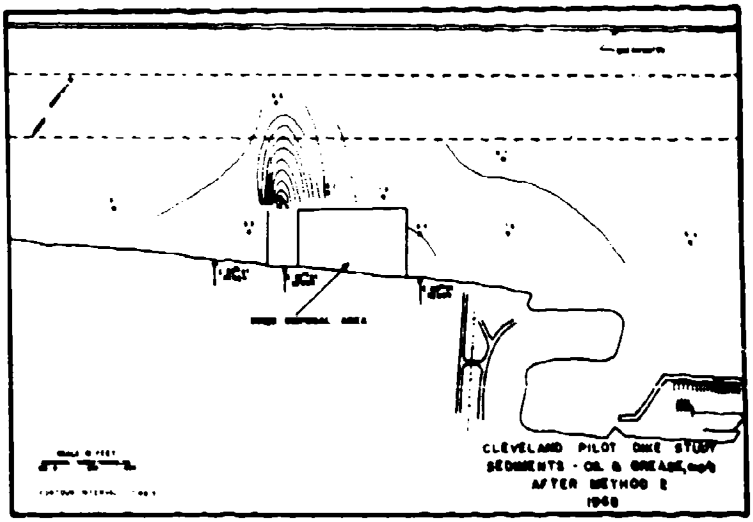

FIGURE 30

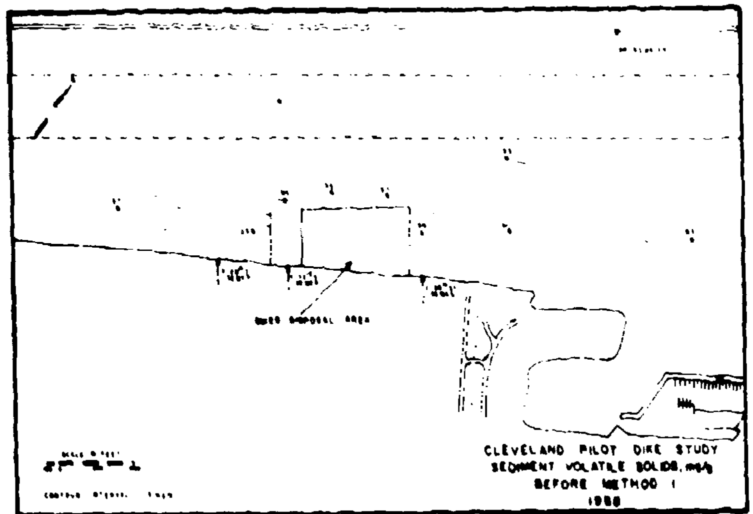

FIGURE 31

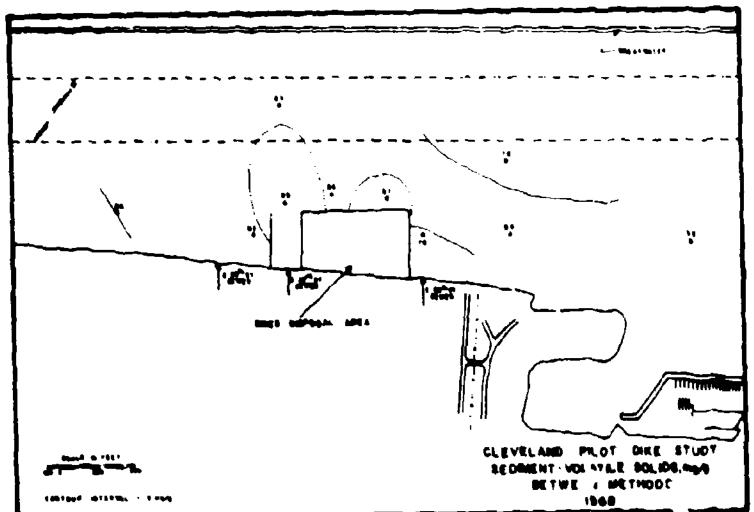

FIGURE 32

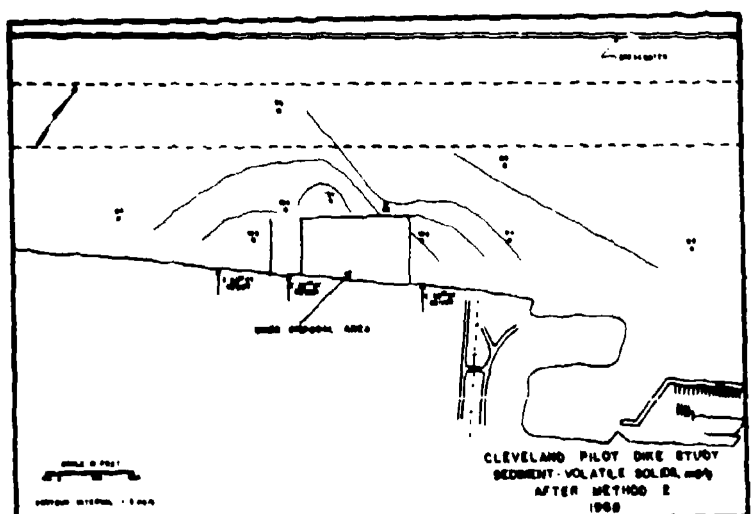

FIGURE 33

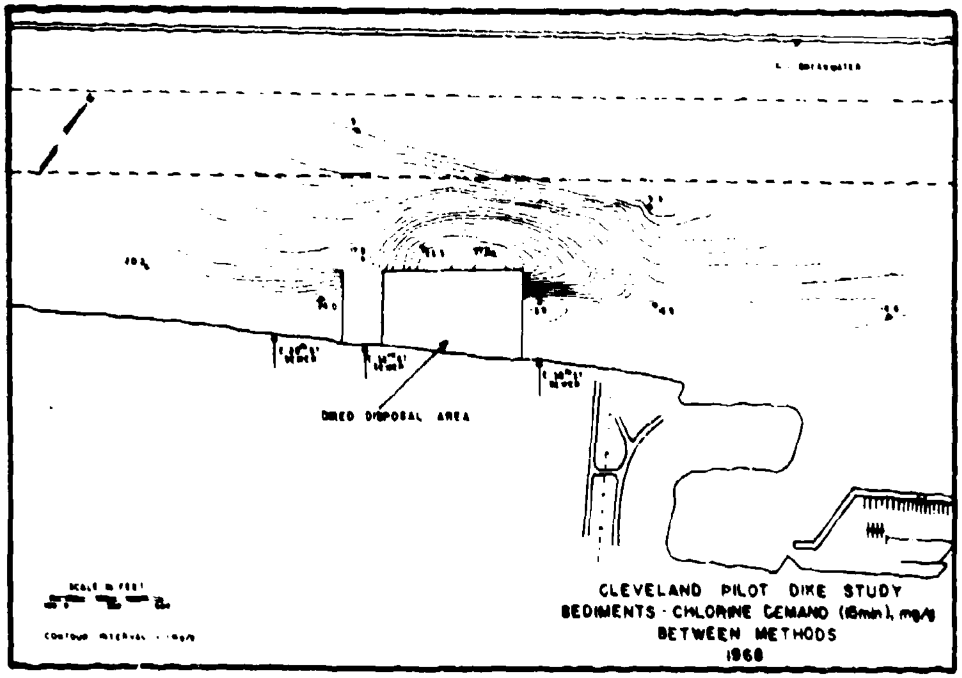

FIGURE 34

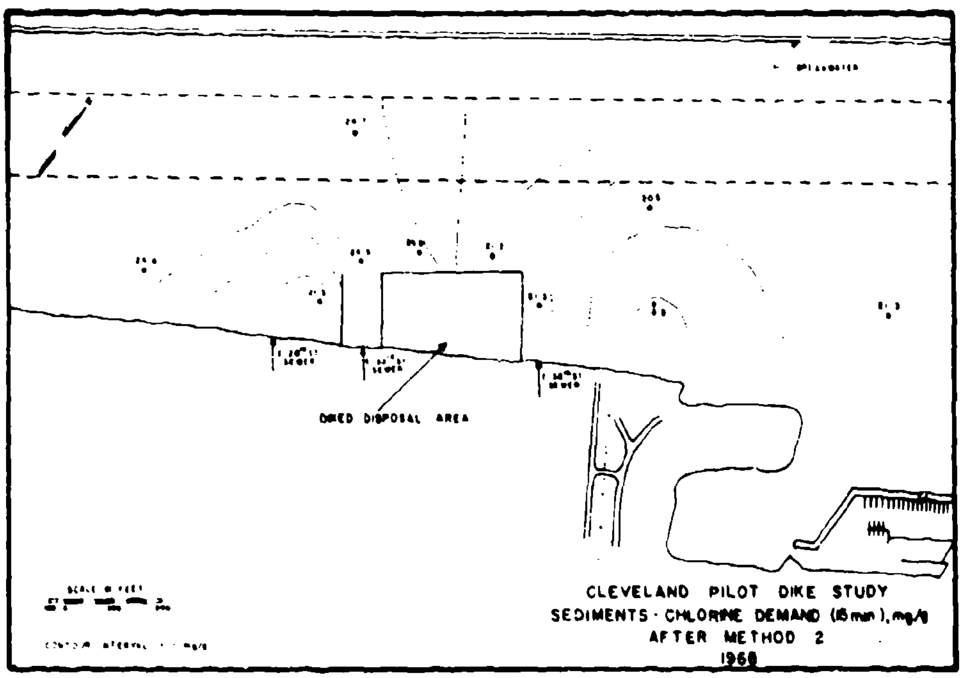

FIGURE 35

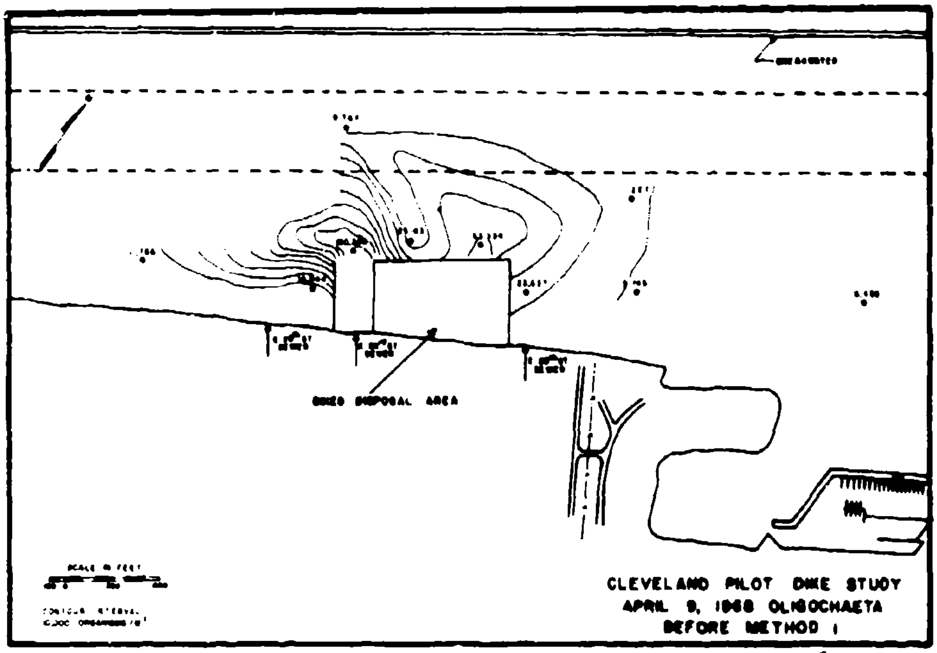

FIGURE 36

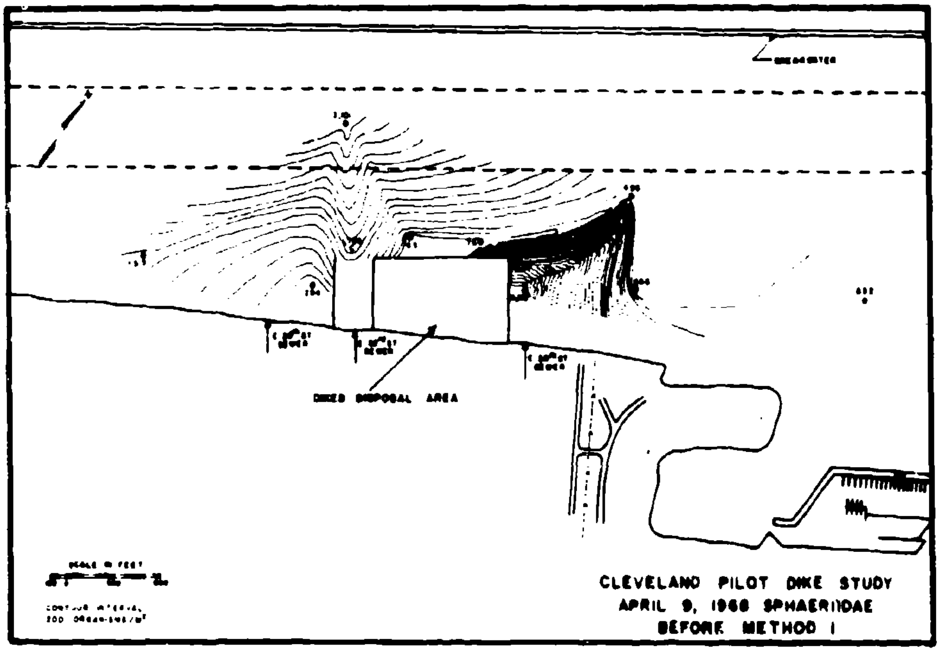

FIGURE 37

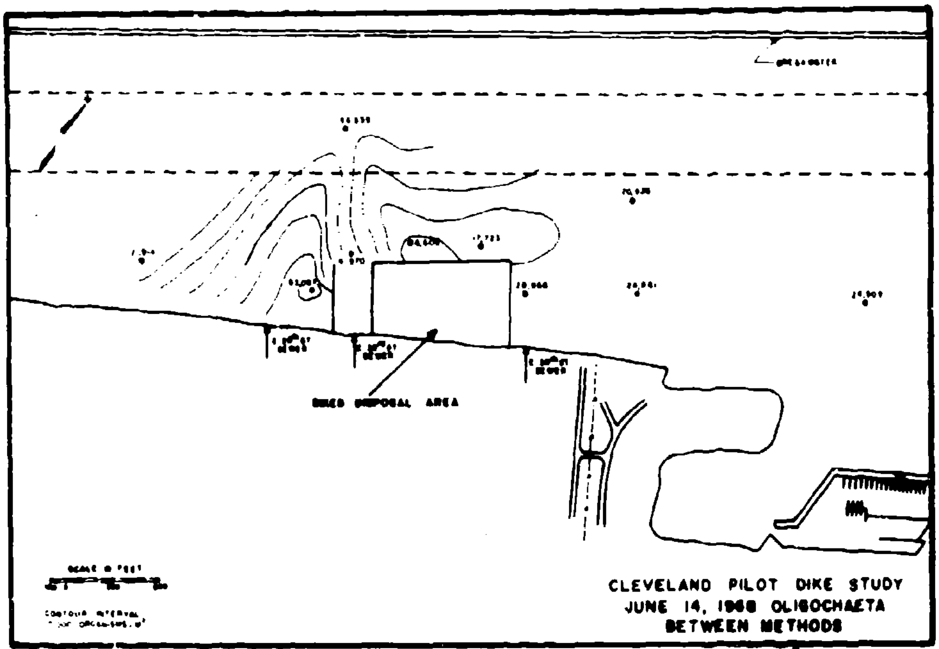

FIGURE 38

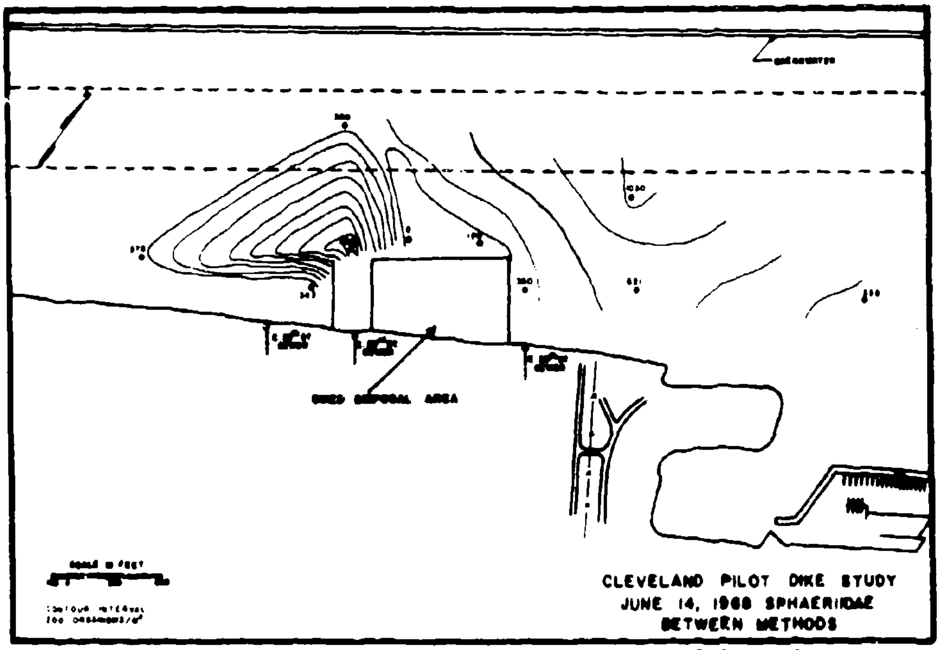

FIGURE 39

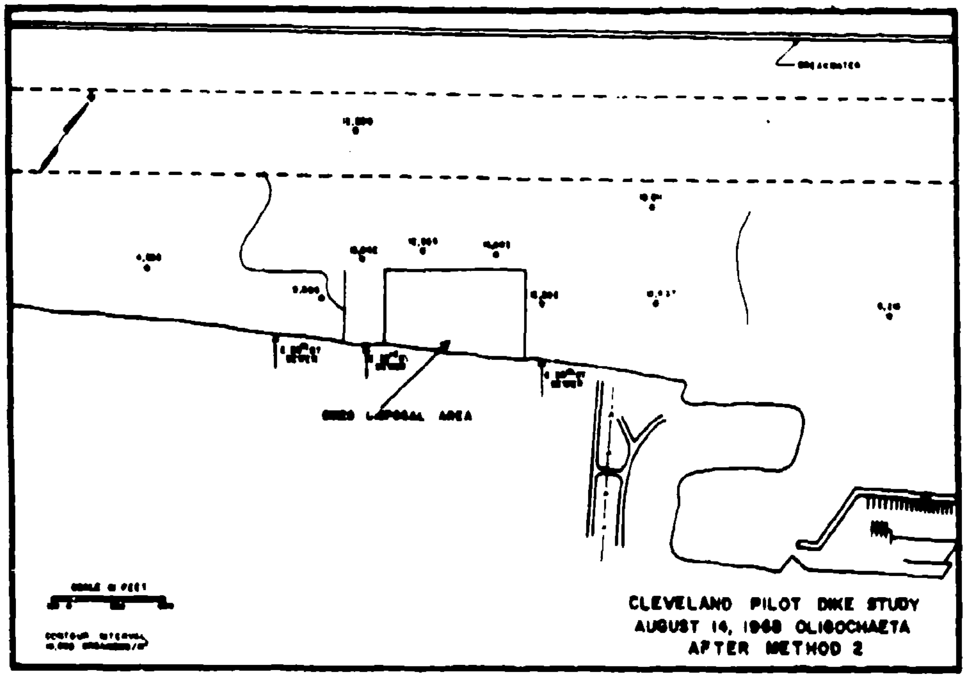

FIGURE 40

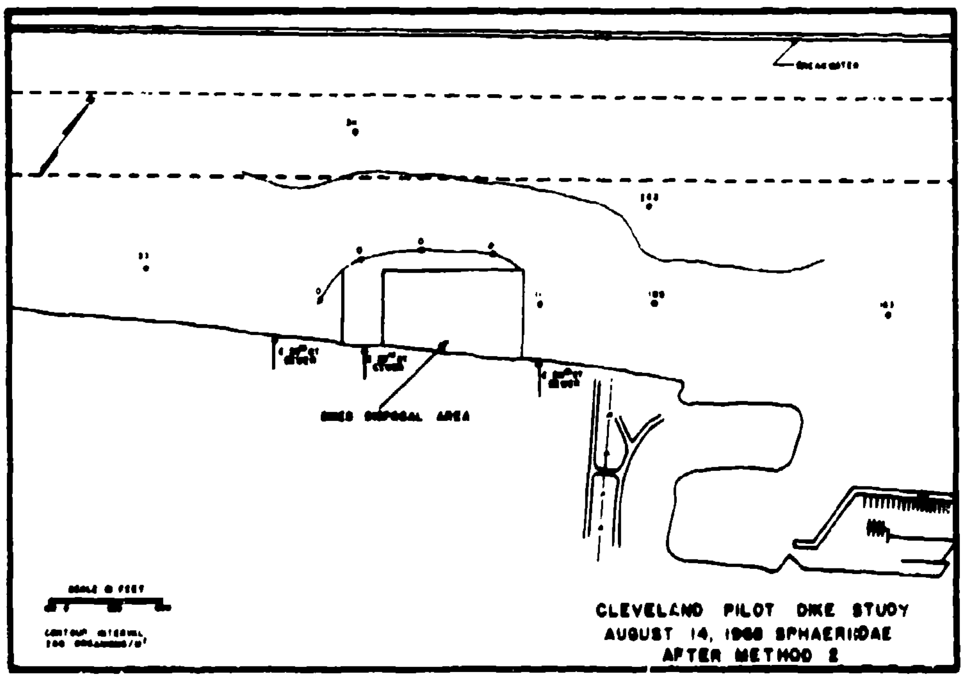

FIGURE 41

population showed a general reduction and remarkable uniformity in areal population distribution.

Sludgeworm population pulses occur naturally in winter, spring, and summer, with a reduction in fall. The reduction after completion of disposal may have been a part of a natural cycle, but it may also have been a result of a sediment change.

Fingernail clams (Figures 37, 39, and 41) were dramatically reduced in population during the first method of disposal and even further during the second. Patterns of relative abundance were similar in all cases with fewer numbers near the dike. After completion of disposal none were found adjacent to the dike.

Fingernail clams also have certain normal growth cycles. Their numbers are relatively constant through winter, spring, and summer until August when a peak occurs. The population during this study did not fit that pattern, indicating a harmful influence. It is likely that that influence was disposal effluent coupled with effects of sewer discharges. The introduction of a toxic substance from the diked area is suggested. Although Cuyahoga River sediments contain many substances which are more or less toxic, it is not known which or how much are required to eliminate a benthic organism population.

CHANGES IN LAKE ERIE WATER QUALITY DUE TO DIKED DISPOSAL

The quality of Lake Erie water has not been measurably affected by the diked disposal effluent. It is likely that more than 99 percent (Table 6) of nearly all the disposed sediment constituents have been permanently removed from the lake ecosystem. Compare this with normal waste treatment procedures and the removal seems astounding. Although the retention efficiency might decrease with increased disposal pumping, it probably would still be greater than 95 percent. Thus, whatever the effect upon Lake Erie, it would be 5 percent or less of the effect caused by open-lake dumping.

The nutrient phosphorus is now considered the principal controllable factor in the degradation of Lake Erie water quality. Diked disposal removes nearly all of the sediment-contained phosphorus, whereas with open-lake dumping, under the influences of currents and wave transport ano lake bottom chemistry phenomana, the sediment contained phosphorus must be considered as potentially available to the water as a nutrient. Thus diked disposal, especially in Cleveland Harbor where most of the waste phosphorus resides in the sediments, is considered as offering a highly efficient method for removing phosphorus from the lake system.

Most other constituents, in addition to phosphorus, are efficiently removed from the system by diked disposal as opposed to direct dumping in the lake. Included in this removal are oxygen-demanding substances, general turbidity, debris, oil, and heavy metals. Kjeldahl nitrogen at a comparatively low 93 percent removal (Table 6) is still efficiently retained.

SUMMARY CONCLUSIONS

The conclusions which follow are based only upon the investigation of the Cleveland Pilot dike. The diked area was small and the rate of disposal was low. Had the area been filled with dredged material, it is likely that some additional conclusions might have been drawn.

The dike was very effective in the containment of dredgings. More than 99 percent of nearly all measured constituents were retained.

General water quality changes due to diked disposal in the Cleveland outer harbor could not be detected except in the vicinity of the dike. Changes due to other causes, such as river and sewer discharges, are infinitely greater.

Pumping the dredgings directly from scows into the diked area caused little or no disturbance to the harbor environment.

Dumping sediments into the slip and pumping them from there into the diked area caused a marked disturbance of water quality in the vicinity of the slip. Tug propellor wash greatly reinforced the disturbance. The effects were measurable to some degree in sediment and water chemistry and benthic biology, and degradation was indicated.

Aerobic conditions and relatively good water quality within the diked area before disposal were transformed rapidly into anaerobic and noxious conditions shortly after disposal began. Water constituents such as dissolved solids rose to high concentrations and leveled off after two or three weeks of disposal.

High porosity of the dike allowed no measurable head to be developed within the diked area and thus the dike probably did not have a great filtering effect, except in the retention of floating debris and oil.

Heads were developed both inside and outside the dike due to normal lake level changes. Flow through the dike exceeded flow from disposal pumping most of the time. These lake level induced flows may have diluted concentrations within the dike by some unknown amount, presumably small.

A portable treatment plant was effective in removing constituents from the diked water. Coagulation, with filtration and chlorination, was most effective. Filtration only was least effective.

Constituent concentrations in the diked water were less during the second method of disposal, probably attributable to the greater quantities of pumping dilution water used. Total effluent loads were essentially similar for both methods.

WORKING DRAFT

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RECOMMENDATIONS

The pilot dike demonstrated a remarkably high efficiency in containment of dredged materials. It is therefore recommended that Cuyahoga River dredgings be entirely disposed of in a similar manner.

Further recommendations are as follows:

1. A diked area should be filled to above lake level as quickly as possible to prevent leaching of unwanted constituents from the sediments at the sediment-water interface.
2. A disposal area with effluent reaching the lake should be filled utilizing, as long as possible, the diked water as dilution to facilitate pumping of materials. This will significantly reduce effluent quantities.
3. Sediments should be transferred directly from the transporting unit into the diked area if possible.
4. During the later stages of filling a diked area when detention time becomes very low, treatment by at least coagulation may be required to maintain effluent quality.

The above recommendations apply only if dredgings are to be disposed of within a diked area draining to the lake which appears at present to be the most feasible.

The Cleveland outer harbor dredgings do not appear to be completely acceptable for dumping into the lake. Unless their quality improves it is likely that contained disposal will be recommended in the near future. In the interim it is recommended that they be dumped in the lake at least ten miles from shore in areas (mud) of greatest similarity in present properties. It is further recommended that the practice of dumping dredgings in the dumping grounds adjacent to the lake side of the harbor breakwall be immediately discontinued for all river and harbor sediments. Dumping in this area interferes with several water uses and is esthetically unpleasant. In addition it is changing a natural sand and gravel bottom to relatively noxious mud over an increasingly wider area. These muds tend to increase turbidity in the Cleveland nearshore area, smother desirable bottom fauna and some may even return to the harbor.

APPENDIX A6

PILOT STUDY OF ROUGE RIVER DREDGING

AUGUST - DECEMBER 1967

U.S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Great Lakes Region
Detroit Program Office
U.S. Naval Air Station
Grosse Ile, Michigan

ROUGE RIVER PILOT STUDY

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PURPOSE

The Rouge River Pilot Study was conducted to determine the degree and extent of pollution caused by the dredging operations on the Rouge River and the associated dumping of the dredged material on to Grassy Island.

SCOPE

The results of the study include water quality measurements in the Rouge and Detroit Rivers during the period of dredging, chemical characteristics of the undisturbed and dredged bottom sediments, water quality of discharges from the dumping grounds, and the quality of water found in the Grassy Island wells.

The quality of industrial and municipal discharges during the study and variations in flow characteristics of the Detroit and Rouge Rivers during the same period were not determined.

ORGANIZATION

The Rouge River Pilot Study was a cooperative effect of the Detroit District of the U.S. Army Corps of Engineers and the Detroit Program Office of the Federal Water Pollution Control Administration.

ACKNOWLEDGEMENTS

The Detroit Program Office received assistance in the preparation of this report from several individuals and organizations including the U.S. Army Corps of Engineers and the City of Wyandotte.

SUMMARY

1. Both the undisturbed and dredged Rouge River bottom sediments are grossly polluted, containing high concentrations of oil, iron and volatile solids. (pages 7-15, 95 and 96)

2. The dredging operation causes significant increases in concentrations of suspended solids, COD, BOD, total phosphate, volatile suspended solids, and iron in the immediate vicinity of the dredge. (pages 94 and 97)

3. The most severe pollution caused by the dredging operation was observed during the overflow of the hopper bins. (pages 45-48)

4. Decreased transparencies were observed in the dredging area for up to an hour after the passing of the dredge. (pages 45 and 48)

5. Decreases in the dissolved oxygen concentration were observed in the dredging area after the dredge had passed. (pages 45 and 48)

6. Levels of polluting constituents decreased substantially at a distance one-half mile downstream from the dredging activity. (pages 94 and 97)

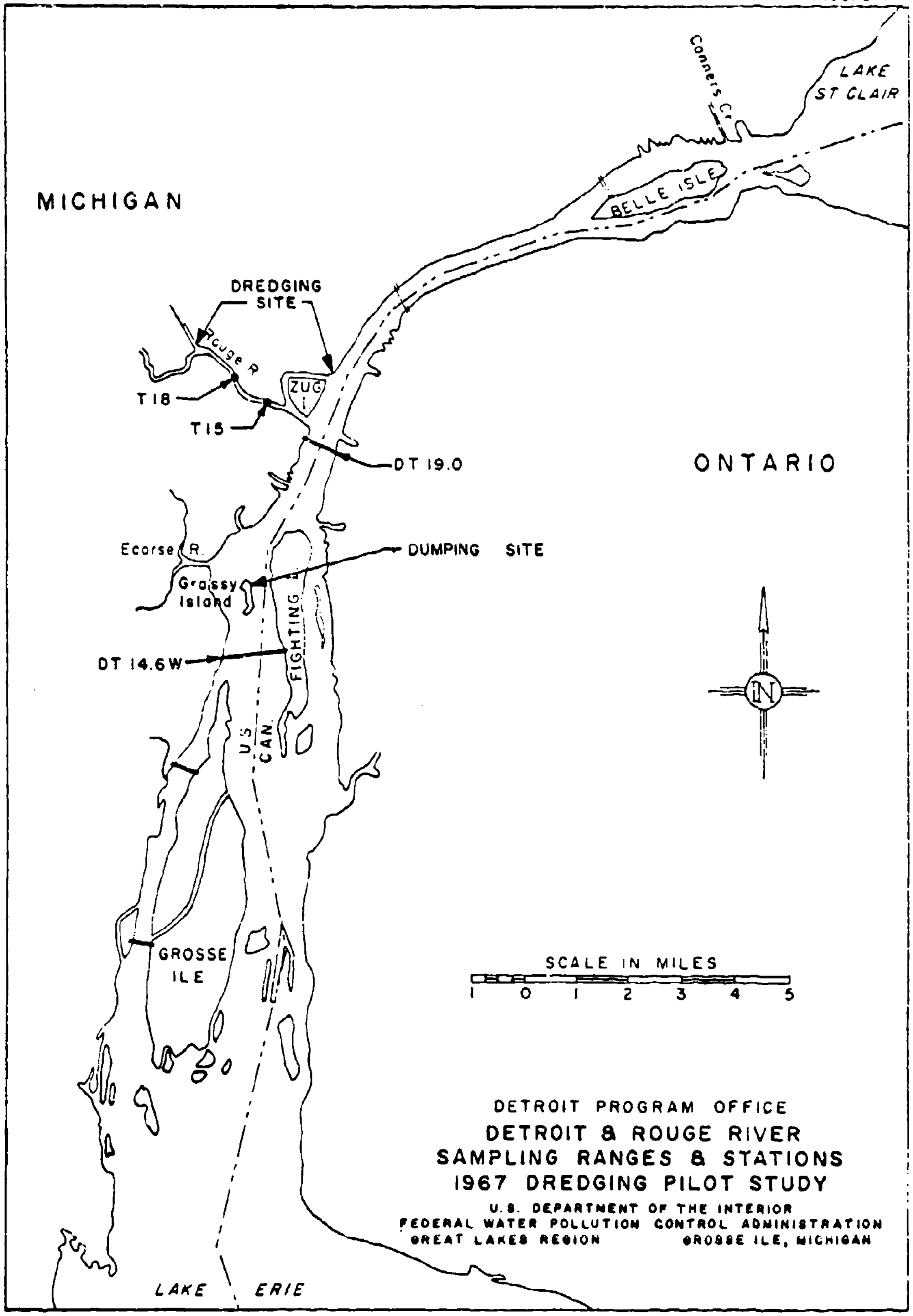
7. Detention of the homogeneous dredged material in the hopper bins provided for 47% solids removal before overflow. (pages 95 and 96)

8. Water quality changes in the Detroit River could not be attributed to either the dredging or disposal operations. (page 94)

9. The seepage rate from the Grassy Island dumping grounds is low. (page 98)

10. The Grassy Island pond acts as a stabilization and settling pond. (page 98)

FIGURE 1



DETROIT PROGRAM OFFICE

DETROIT & ROUGE RIVER
SAMPLING RANGES & STATIONS
1967 DREDGING PILOT STUDY

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION GROSSE ILE, MICHIGAN

INTRODUCTION AND BACKGROUND

The Rouge River rises northwest of Detroit and flows southeasterly, emptying into the Detroit River at a point 19 miles north of Lake Erie.

The lower 3.5 miles of the river lies in an area dominated by heavy industry. Allied Chemical Corporation, American Agricultural Chemical Company, Darling and Company, Ford Motor Company, American Cement Corporation, and Scott Paper Company have outfalls on the Rouge River which discharge nearly 500 million gallons of cooling and process water each day. Principal waste constituents discharged are: iron, oxygen-demanding substances, bacteria, suspended solids, oil, pickle liquor, phenols, chlorides, cyanides, toxic metals, and ammonia. In additon, the Detroit sewage treatment plant discharges over 500 MGD of primary effluent into the Detroit River near the mouth of the Rouge River. There are also numerous stormwater outfalls which discharge into the Rouge and Detroit Rivers. An overflow can be considered to occur for all rainstorms greater than .2 inches total precipitation per day. The record of daily precipitation reported at Detroit Metropolitan Airport is shown in Table 1.

The main sources of pollution on the Rouge and Detroit Rivers are discussed in detail in the "Proceedings of the Conference in the Matter of Pollution of the Navigable Waters of the Detroit River and Lake Erie and their Tributaries in the State of Michigan, Second Session June 15-18, 1965." Industrial waste outfalls are shown in Volume 1, page 217A, and the average concentrations of the waste constituents are listed in Volume II, pages 374, and 375. The sewage plant outfalls and stormwater overflows are shown in Volume 1, page 226, and the summary of the Domestic Waste Surveys.

FWPCA, DPO

Table 1
- Metropolitan Airport -
Detroit, Michigan
Precipitation
(Total Water Equivalent, Inches)
1967

Aug.	21	0
Aug.	22	trace
Aug.	23	0
Aug.	24	0
Aug.	25	0
*Aug.	26	.[illegible]
Aug.	27	.04
Aug.	28	.12
Aug.	29	trace
*Aug.	30	.34
Aug.	31	0
Sept.	1	0
Sept.	2	0
Sept.	3	0
Sept.	4	0
Sept.	5	0
Sept.	6	0
Sept.	7	0
Sept.	8	0
Sept.	9	0
Sept.	10	0
Sept.	11	0
Sept.	12	0
Sept.	13	0
Sept.	14	0
Sept.	15	0
Sept.	16	0
Sept.	17	0
Sept.	18	0
Sept.	19	trace
Sept.	20	.07
*Sept.	21	1.20
Sept.	22	0
Sept.	23	trace
Sept.	24	trace
Sept.	25	0
Sept.	26	0
*Sept.	27	.22
Sept.	28	.04
*Sept.	29	.30
Sept.	30	.13
Oct.	1	0
Oct.	2	0
Oct.	3	0
Oct.	4	0
Oct.	5	[illegible]
Oct.	6	0
Oct.	7	.01
*Oct.	8	1.02
Oct.	9	.03
Oct.	10	.01
Oct.	11	trace
Oct.	12	0
Oct.	13	.08
Oct.	14	trace
*Oct.	15	1.03
*Oct.	16	.39
*Oct.	17	1.70
Oct.	18	.01
Oct.	19	trace
Oct.	20	0
Oct.	21	0
Oct.	22	0
Oct.	23	0
Oct.	24	.03
Oct.	25	trace
Oct.	26	trace
*Oct.	27	.54
Oct.	28	trace
Oct.	29	0
Oct.	30	0
Oct.	31	.02
*Nov.	1	.85
Nov.	2	.18
*Nov.	3	.49
Nov.	4	.02
Nov.	5	.01
Nov.	6	trace
Nov.	7	trace
Nov.	8	trace
Nov.	9	0
Nov.	10	.05
*Nov.	11	.26
Nov.	12	.02
Nov.	13	.04
Nov.	14	.11
Nov.	15	0
Nov.	16	0
*Nov.	17	.34
Nov.	18	.11
Nov.	19	0
Nov.	20	0
Nov.	21	.13
Nov.	22	.11
Nov.	23	trace
Nov.	24	0
Nov.	25	trace
Nov.	26	trace
Nov.	27	trace
Nov.	28	.03
Nov.	29	trace
Nov.	30	.02
Dec.	1	0
*Dec.	2	.73
Dec.	3	.05

*Probable stormwater overflows

is shown in Volume II, pages 363 and 364.

Continual accumulation of bottom sediments from effluents discharged to the Rouge River and from natural runoff necessitates annual maintenance dredging of the naviagation channel in the lower river. Each year, a U.S. Corps of Engineers' hopper dredge removes over 100,000 cubic yards of bottom sediments from the Rouge River. The following table indicates the dredging activities which have been undertaken in the Rouge River in the last six years. The bin volume is the amount of sludge actually deposited on Grassy Island from the dredge. The place volume indicates the amount of undisturbed material removed from the Rouge.

Corps of Engineers
Maintenance Dredging
Rouge River
1962-1967

Dredging Period	Bin Volume (cu. yds.)	Place Volume (cu. yds.)
October - December 1962	148,000	95,000
September - December 1963	160,000	102,000
September 18 - December 17, 1964	253,000	171,000
October 1 - December 17, 1965	209,000	125,000
September 26 - December 17, 1966	281,000	119,000
August 25 - November 16, 1967	342,000	222,000

The Grassy Island dumping grounds, covering an area of 80 acres, is located on the American side of the Detroit River approximately four miles south of the mouth of the Rouge River. Grassy Island was formerly a low swampy area at approximately river level. In 1960, the Corps of Engineers completed construction of an earth dike of clay material approximately 6 feet high around the perimeter of the island to contain the spoil from Rouge River dredging. As now constructed there is no overflow weir. There is however, a valved drain pipe which is used to remove water after settling.

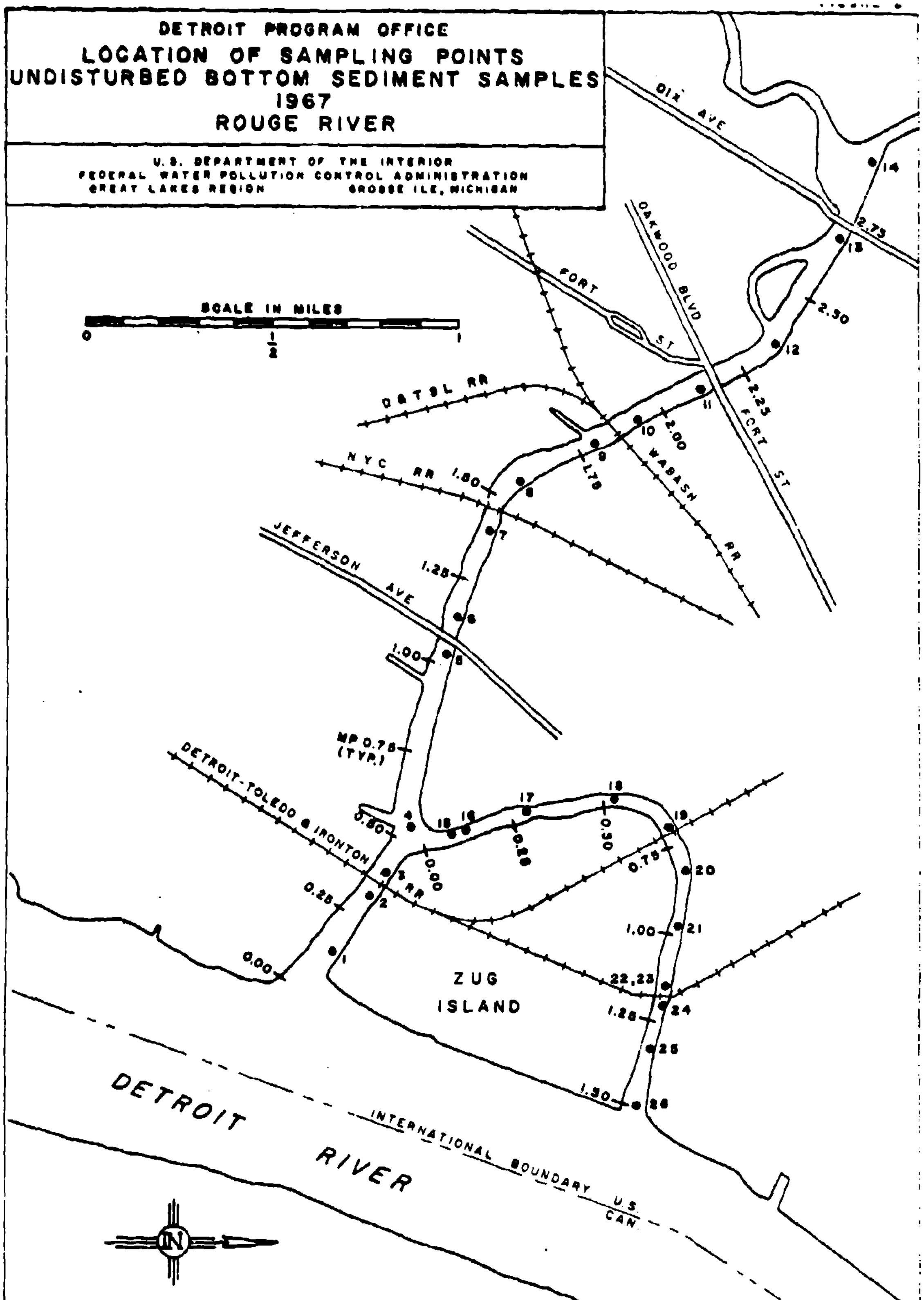
On a typical dredging and dumping run of two to three hour duration, the dredge, with its hoppers loaded with Rouge River bottom sediments, traveled south down the Detroit River to Grassy Island. Upon reaching the island, the dredge was hooked up to the inflow pipe and its load was pumped on to the island through one branch of the Y-shaped piping system (shown in Figure 7). After unloading, the dredge returned to the Rouge River to repeat the cycle.

I. INVESTIGATION PROCEDURES AND DATA

A. Dredging Site - Rouge River

Characteristics of Undisturbed Bottom Sediments

In order to determine the characteristics of the undisturbed bottom sediments, sludge samples were collected with the Petersen dredge along the length of the Rouge River prior to the commencement of the dredging operations. Fourteen samples were collected in the main stem of the Rouge from Ford Motor Company turning basin to the mouth of the Short-cut Canal. Twelve additional bottom sediment samples were collected in the Old Channel of the Rouge. The sampling stations are shown in Figure 2 and the results of the analysis of the sludge as shown in Table 3. Explanation of the material and descriptions listed in Table 3 is given on pages 7 and 8.


DETROIT PROGRAM OFFICE
LOCATION OF SAMPLING POINTS
UNDISTURBED BOTTOM SEDIMENT SAMPLES
1967
ROUGE RIVER
U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION GROSSE ILE, MICHIGAN
SCALE IN MILES
0
1/2
1
DIX AVE
FORT ST
OAKWOOD BLVD
FORT ST
D & T S L RR
N Y C RR
WABASH RR
JEFFERSON AVE
DETROIT-TOLEDO & IRONTON RR
MP 0.75
(TYP.)
ZUG
ISLAND
DETROIT
RIVER
INTERNATIONAL BOUNDARY U.S.
CAN.
N

Description of Bottom Material

The descriptions of bottom materials are listed in Table 2. The sediments were classified as follows:

Ooze: soft, fine, decaying organic material.

Sludge: (clay, silt, mud or organic material): non-gritty material of natural or unnatural origin.

Sand: gritty particles up to 1/25" in diameter

Gravel: 1/25" to 1/4"

Pebbles: 1/4" to 2"

Stones: 2" to 10"

Table 1
Qualitative Descriptions of Odors*
FWPCA, DPO, 1967

Code	Nature of Odor	Description (Such as Odors of:)
A	Aromatic (spicy)	camphor, cloves, levender, lemon
Ac	cucumber	Synura
B	Balsamic (flowery)	geranium, violet, vanilla
Bg	geranium	Asterionella
Bn	nasturtium	Aphanizomenon
Bs	sweetish	Coelosphaerium
Bv	violet	Mallomonas
C	Chemical	industrial wastes or treatment chemicals
Cc	chlorinous	free chlorine
Ch	hydrocarbon	oil refinery wastes
Cm	medicinal	phenol and iodoform
Cs	sulfuretted	hydrogen sulfide
D	Disagreeable	(pronounced, unpleasant)
Df	fishy	Uroglenopsis, Dinobryon
Dp	pigpen	Anabaena
Ds	septic	stale sewage
E	Earthy	damp earth
Ep	peaty	peat
G	Grassy	crushed grass
M	Musty	decomposing straw
Mm	moldy	damp cellar
V	Vegetable	root vegetables

*Standard Methods of Examination of Water & Wastewater, 11th Edition, p. 255

FWPCA, DPO

Rouge River Pilot Study - 1967
Undisturbed Bottom Sediment

Table 3

SAMPLE NO.	MILE POINT	CORPS. DESIGNATION	DATE	LAB. NO.	TEMP. °C	GROSS DESCRIPTION (Description; odor*)
Main R[illegible]						
at D.R.	.00					
1	.14	29-26	7-18	29754	19.0	Black, gray sludge & coal
2	.33	27-19	7-18	29755	19.5	Black ooze & pulpwood, sludge worms
3	.40	25-29	7-18	29757	19.5	Gray sludge; D (decomposing wood)
4	.55	24-27	7-18	29756	19.5	Gray sludge & ooze; D (decomposing wood)
5	1.05	21-23	7-19	29763	21.0	Dark-gray sludge; C_h
6	1.15	19-22	7-19	29764	22.0	Dark-gray sludge; C_h
7	1.40	17-22	7-19	29765	20.0	Dark gray sludge & ooze; C_h
8	1.57	15-26	7-19	29766	21.0	Dark gray sludge & ooze; C_h
9	1.80	13-17	7-19	29767	21.0	Dark gray sludge & ooze; C_h
10	1.93	11-24	7-19	29768	22.0	Dark gray sludge; C_h, D, M
11	2.14	9-19	7-26	30751	23.5	Dark gray sludge & ooze; C_h
12	2.37	7-23	7-26	30752	24.0	Dark gray sludge & ooze; trace oil & iron oxide; [illegible]
13	2.71	5-20	7-19	29769	24.0	Dark gray sludge, ooze, trace oil & iron oxide; C_h
14	2.94	2-18	7-19	29770	24.0	Dark sludge, ooze, trace oil & iron oxide; C_h
Old Channel						
Cutoff	.00					
15	.08	32-20	7-18	29762	20.0	Gray sludge & pulpwood; D (decomposing wood), C_h
16	.12	34-	7-18	29758	20.0	Gray sludge & pulpwood; D (decomposing wood), C_r
17	.29	36A-21	7-18	29759	27.0	Gray sludge, trace oil; C_h
18	.52	36-17	7-18	29760	24.0	Gray sludge & pulpwood, sludge worms, trace oil; D
19	.70	38-21	7-18	29761	20.0	Gray sludge & ooze, some sand, C_m, C_h, D
20	.82	39-20	7-18	29750	22.0	Dark gray sand, sludge & ooze; C_m, C_h
21	.93	40-22	7-18	29749	23.0	Dark gray sand, sludge, stones, pebbles; C_m, C_h
22	1.15	42-24	7-18	29748	22.0	Dark gray gravel, pebbles & sand; C_m, C_h
23	1.15	42-24	7-26	30750	19.0	Dark gray ooze, sand & pebbles, sludge worms; C_m, C_h
24	1.20	43-14	7-18	[illegible]	19.0	Light gray sludge; C_m, C_h
25	1.32	45-21	7-18	[illegible]	19.0	Gray sludge & ooze, some clay; D_s, D_p, C_h
[illegible]	1.48	46-25	7-18	[illegible]	18.5	Gray sludge & ooze; C_h, D
[illegible]	1.52					

*See Table 2

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Rouge River Pilot Study - 1967
Undisturbed Bottom Sediment

Table 3 (cont.)

SAMPLE NO.	IMMED. DO DEM Mg/Kg Wet Basis	COD Mg/Kg Wet Basis	PHENOLS μg/Kg Wet Basis	TOTAL PO_4 Mg/Kg Wet Basis	TOT. SOL. PO_4 Mg/Kg Wet Basis	NITRATE NO_3-N Mg/Kg Wet Basis	NITRITE NO_2-N Mg/Kg Wet Basis	AMMONIA NH_3-N Mg/Kg Wet Basis	ORGANIC NITROGEN Mg/Kg Wet Basis	IRON Mg/Kg Wet Basis	OIL & GREASE Mg/Kg Dry Basis	TOTAL SOLIDS % Wet Basis	VOL SOLIDS % Dry Basis	BOD Mg/Kg Wet Basis
1	100		1300	870	3	80	-	20	30	7800	9000	51	34	10,000
2	70		880	250	4	40	.1	10	30	8500	9000	52	20	11,000
3	-		690	1400	2	< 8	< .05	6	10	7300	1000	66	6	820
4	-		440	2700	2	< 8	.1	30	-	17,000	20,000	48	13	3900
5	80		220	4800	2	< 8	.08	100	60	45,000	40,000	51	19	6700
6	100		440	5000	3	20	.1	300	80	41,000	60,000	45	19	4800
7	100		340	1800	4	8	.06	50	60	43,000	50,000	35	17	5400
8	100		1900	3800	1	90	.05	50	80	43,000	40,000	36	18	10,000
9	200		780	4500	< 1	10	.06	70	-	50,000	50,000	39	18	6700
10	100		1000	2900	3	10	.05	60	40	39,000	30,000	40	14	6700
11	500		410	3900	5	30	< .05	-	-	59,000	50,000	45	16	8500
12	500		2100	1700	4	20	< .05	50	200	50,000	60,000	40	15	14,000
13	100		< 190	2700	2	20	.06	70	60	44,000	30,000	44	11	2200
14	100		590	1700	4	10	< .05	100	100	55,000	40,000	39	18	5800
15	-		440	660	1	8	< .05	40	20	6500	20,000	28	35	5800
16	-		1500	760	2	20	< .05	30	40	3600	20,000	28	16	9100
17	-		690	1300	< 1	10	< .05	70	80	6800	10,000	48	11	4800
18	-		1200	1400	2	< 8	.05	60	30	10,000	10,000	56	15	1700
19	-		1500	1400	2	< 8	< .05	20	40	16,000	1,000	65	16	2700
20	90		1300	1300	2	40	.09	-	-	14,000	20,000	56	22	8200
21	40		2600	190	2	60	.1	30	9	11,000	5,000	81	10	3800
22	60		5600	3600	5	20	.1	30	8	22,000	40,000	73	12	9100
23	40		1800	1000	6	10	< .05	50	-	9400	60,000	44	18	9200
24	30		1000	520	1	8	.1	8	40	3000	9,000	47	11	6700
25	60		1200	920	3	70	.08	8	50	6600	10,000	37	16	9100
26	70		1100	440	1	200	.06	50	20	10,000	2,000	43	12	2700

Dredged Sludge (Intake and Overflow)

In order to determine the characteristics of the dredged sludge, samples were collected from the intake of the hopper dredge. The material, as it flowed with varying consistency into the hopper from an inflow chute, was collected with a metal bucket suspended from a rope. Samples collected after October 12 were composites of the inflow from both side of the dredge.

Samples were also collected from the overflow material. These samples were collected with a metal bucket at the edge of the hopper as the material overflowed into the river. The results of the chemical analysis of both the intake and overflow material are shown in Tables 4 and 5. The conclusions regarding the dredged sludge are discussed on pages 95 and 96.

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TABLE 4
HOFFMAN INTAKE

Date	IMMED. OO DEM Mg/Kg Wet Basis	COD Mg/Kg Wet Basis	PHENOLS ug/Kg Wet Basis	TOTAL PO_4 Mg/Kg Wet Basis	TOT. SOL PO_4 Mg/Kg Wet Basis	NITRATE NO_3-N Mg/Kg Wet Basis	NITRITE NO_2-N Mg/Kg Wet Basis	AMMONIA NH_3-N Mg/Kg Wet Basis	ORGANIC NITROGEN Mg/Kg Wet Basis	IRON Mg/Kg Wet Basis	OIL & GREASE Mg/Kg Dry Basis	TOTAL SOLIDS % Wet Basis	FIXED SOLIDS % Dry Basis	VOL. SOLIDS % Dry Basis
8-31	-	68,000	1,100	2,800	3	20	0.3	200	50	40,000	40,000	40	86	14
9-7	1,000	24,000	2,200	2,600	3	30	0.07	200	40	46,000	20,000	62	51	49
9-14	800	86,000	610	3,000	3	40	0.07	200	40	42,000	40,000	40	85	15
9-21	500	130,000	890	3,600	2	10	0.08	80	20	38,000	40,000	39	85	15
10-5	400	68,000	2,000	1,900	3	20	0.09	100	40	24,000	40,000	23	86	14
10-12	700	150,000	940	4,400	4	20	0.05	200	70	50,000	50,000	42	80	20
10-19	500	97,000	1,000	2,700	<1	10	0.06	100	40	24,000	50,000	26	83	17
10-29	50	44,000	990	550	3	<8	<0.05	40	40	5,100	10,000	22	84	16
11-8	600	120,000	850	40		< 8	< 0.05	10	2	24,000	40,000	36	83	17

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TABLE 5
HOFFMAN OVERFLOW

Date	IMMED. DO DEM Mg/Kg Wet Basis	COD Mg/Kg Wet Basis	PHENOLS ug/Kg Wet Basis	TOTAL PO_4 Mg/Kg Wet Basis	TOT. SOL. PO_4 Mg/Kg Wet Basis	NITRATE NO_3-N Mg/Kg Wet Basis	NITRITE NO_2-N Mg/Kg Wet Basis	AMMONIA NH_3-N Mg/Kg Wet Basis	ORGANIC NITROGEN Mg/Kg Wet Basis	IRON Mg/Kg Wet Basis	OIL & GREASE Mg/Kg Dry Basis	TOTAL SOLIDS % Wet Basis	FIXED SOLIDS % Dry Basis	VOL. SOLIDS % Dry Basis
8-31		53000	660	2200	2	20	0.06	70	20	31000	70000	23	79	21
9-7	500	50000	750	1800	1	20	< 0.05	90	90	25000	40000	22	85	15
9-14	400	63000	1000	2300	2	20	0.07	100	30	23000	60000	22	84	16
9-21	300	-	1400	1900	1	10	0.07	200	40	17000	50000	19	85	15
10-5	200	66000	1500	1600	2	10	0.08	100	20	20000	40000	19	86	14
10-12	200	61000	810	1500	4	10	< 0.05	30	40	17000	70000	15	79	21
10-19	300	25000	1100	2200	< 1	< 8	< 0.05	60	30	17000	50000	21	84	16
10-29	30	30000	380	480	2	< 8	< 0.05	30	30	5000	20000	16	86	14
11-8	100	23000	490	17		< 8	< 0.05	< 1	70	13000	40000	16	85	15

Dredging Operation

The study of the dredging operation was conducted to determine the pollutional effect of dredging on the water quality of the Rouge and Detroit Rivers. Water quality changes caused by dredging operations must be distinguished from changes occurring as a result of changes in effluent of the numerous pollution sources.

Station T15 (Jefferson Street bridge) and Station T18 (Fort Street bridge) on the Rouge River and R139 and R142 (on range DT 19.0, 100 and 400 feet from U.S. shore, respectively) on the Detroit River were sampled at mid-depth each week to determine water quality at these fixed points as the dredging progressed downriver. These stations are shown on Figure 3 and the results of the analyses as related to the position of the dredging operation are listed in Table 6 .

Water quality determinations of mid-depth samples were also made in the vicinity of the dredging operation. Samples collected in the stirred-up material about 50 feet behind the dredge during hopper overflow were analyzed to determine the worst condition created by the dredging. The sample collected 1/4 mile upstream reflects the water quality of the river unaffected by dredging. The analysis of the sample collected (1/4 mile and 1/2 mile) downstream shows the extent of the pollution. The results of the analyses are shown in Table 6 .

FIGURE 3

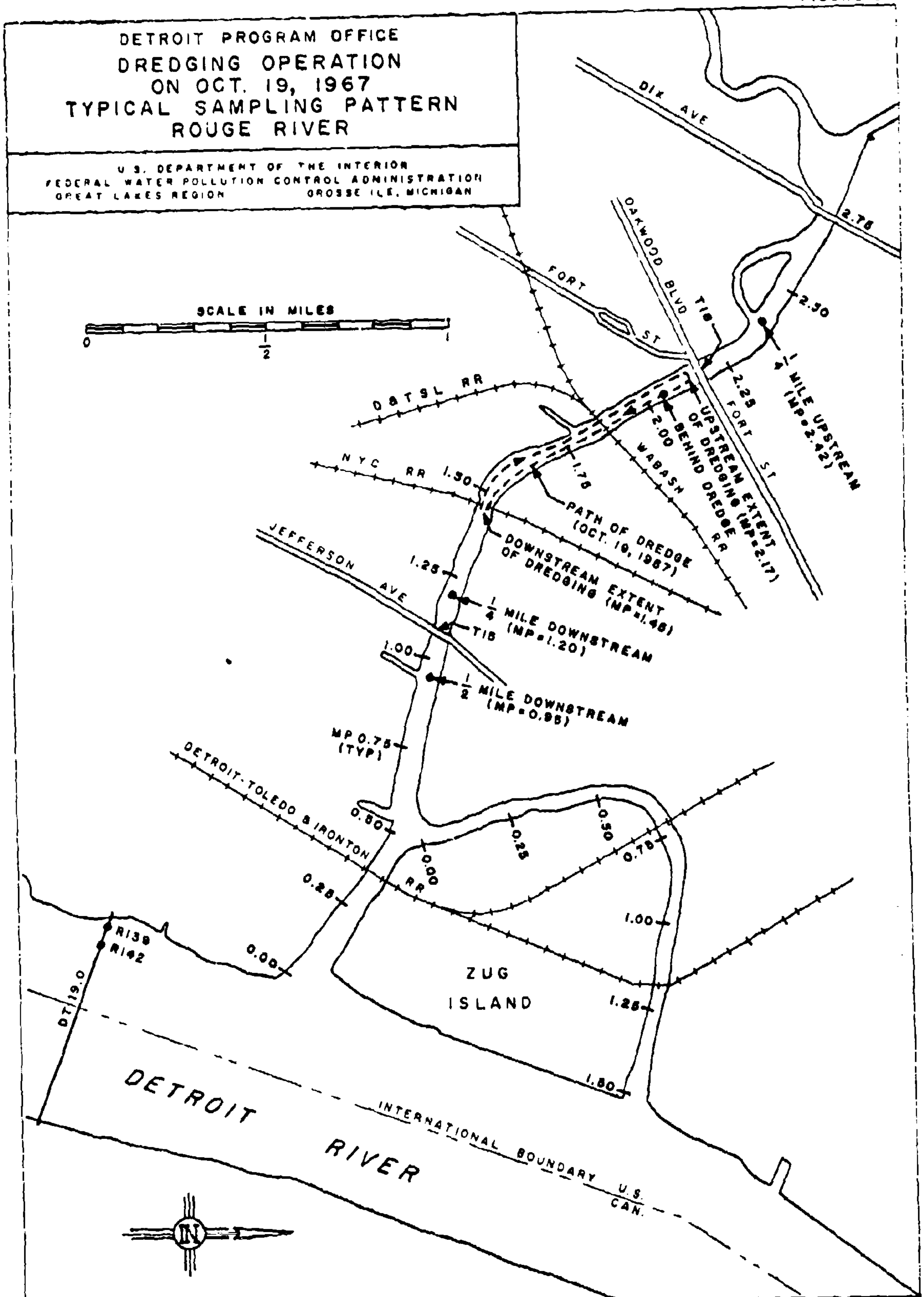

DETROIT PROGRAM OFFICE
DREDGING OPERATION
ON OCT. 19, 1967
TYPICAL SAMPLING PATTERN
ROUGE RIVER
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION GROSSE ILE, MICHIGAN
SCALE IN MILES
0
1/2
1
DIX AVE
OAKWOOD BLVD
FORT ST
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
T18
1/4 MILE UPSTREAM (MP=2.42)
UPSTREAM EXTENT OF DREDGING (MP=2.17)
BEHIND DREDGE
FORT ST
WABASH RR
D&TSL RR
NYC RR
PATH OF DREDGE (OCT. 19, 1967)
DOWNSTREAM EXTENT OF DREDGING (MP=1.48)
1/4 MILE DOWNSTREAM (MP=1.20)
JEFFERSON AVE
T18
1/2 MILE DOWNSTREAM (MP=0.95)
MP 0.75 (TYP)
DETROIT-TOLEDO & IRONTON RR
0.50
0.25
0.00
0.00
0.25
0.50
0.75
1.00
1.25
1.50
R139
R142
DT 19.0
ZUG ISLAND
DETROIT RIVER
INTERNATIONAL BOUNDARY U.S. CAN.
N

TABLE 6
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Temperature (°C)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	27.5	28.0	21.0	21.0
8-31	2.67 to 2.94	-	26.5	27.0	27.0	-	-	-	-
9-7	2.55 to 2.94	27.0	-	27.5	27.0	27.0	26.0	21.5	23.0
9-14	2.40 to 3.00	-	20.5	20.5	20.5	21.5	20.5	19.0	18.5
9-21	1.93 to 2.63	22.5	23.0	22.5	22.0	22.5	22.0	20.5	20.0
10-5	1.87 to 2.69	-	17.0	17.0	17.0	17.0	16.5	16.0	16.0
10-12	1.50 to 2.17	14.5	14.5	15.0	14.5	14.5	14.0	13.0	13.0
10-19	1.45 to 2.17	12.5	12.5	11.5	11.5	11.0	12.0	13.0	12.0
10-29	Old Channel	9.0	8.5	9.0	-	-	-	9.5	8.5
11-8	0.87 to 1.46	12.5	12.5	10.0	8.0	12.0	13.0	6.0	5.0
	Average	16.5	17.0	18.0	18.5	19.0	19.0	15.5	15.0
	Maximum	27.0	26.5	27.5	27.0	27.5	28.0	21.5	23.0
	Minimum	9.0	8.5	9.0	8.0	11.0	12.0	6.0	5.0
	No. Samples	6	8	9	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: pH (standard units)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	6.7	6.9	7.2	7.2
8-31	2.67 to 2.94	-	6.6	-	7.1	-	-	-	-
9-7	2.55 to 2.94	7.3	-	7.4	7.3	7.3	7.4	8.0	7.8
9-14	2.40 to 3.00	-	7.5	7.5	7.6	7.6	7.8	7.5	8.0
9-21	1.93 to 2.63	7.3	7.1	7.4	7.7	7.2	7.4	7.5	7.5
10-5	1.87 to 2.69	-	7.6	7.5	7.6	7.6	7.5	7.5	8.0
10-12	1.50 to 2.17	7.4	7.6	7.5	7.5	7.6	7.6	7.8	8.0
10-19	1.45 to 2.17	7.6	7.5	7.5	7.5	7.5	7.5	7.7	8.0
10-29	Old Channel	8.2	8.1	7.8	-	-	-	7.8	8.0
11-8	0.87 to 1.46	8.0	7.8	7.9	7.9	8.1	8.2	8.1	8.2
	Average	7.6	7.5	7.6	7.5	7.5	7.5	7.7	7.9
	Maximum	8.2	8.1	7.9	7.9	8.1	8.2	8.1	8.2
	Minimum	7.3	6.6	7.4	7.1	6.7	6.9	7.2	7.2
	No. Samples	6	8	8	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Conductivity (umhos/cm)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	300	320	220	240
8-31	2.67 to 2.94	-	410	-	430	-	-	-	-
9-7	2.55 to 2.94	400	-	380	390	390	410	300	300
9-14	2.40 to 3.00	-	350	310	310	310	430	300	240
9-21	1.93 to 2.63	360	690	370	460	410	400	380	240
10-5	1.87 to 2.69	-	300	310	320	300	320	270	210
10-12	1.50 to 2.17	350	370	350	420	350	410	290	230
10-19	1.45 to 2.17	520	510	520	510	510	510	280	220
10-29	Old Channel	210	230	280	-	-	-	290	260
11-8	0.87 to 1.46	430	460	540	460	440	440	270	240
	Average	380	420	380	410	380	400	290	240
	Maximum	520	690	520	510	510	510	380	260
	Minimum	210	230	280	320	300	320	220	210
	No. Samples	6	8	8	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Alkalinity (mg/l as $CaCO_3$)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	46	48	73	77
8-31	2.67 to 2.94	-	34	-	-	-	-	-	-
9-7	2.55 to 2.94	61	-	65	64	64	68	79	77
9-14	2.40 to 3.00	-	91	81	85	83	88	85	79
9-21	1.93 to 2.63	82	94	89	92	88	92	77	77
10-5	1.87 to 2.69	-	87	92	92	87	92	78	79
10-12	1.50 to 2.17	85	89	96	94	83	96	69	76
10-19	1.45 to 2.17	110	110	97	100	110	110	77	72
10-29	Old Channel	76	88	82	-	-	-	81	79
11-8	0.87 to 1.46	93	110	95	82	93	100	78	76
	Average	85	88	87	87	82	87	77	77
	Maximum	110	110	97	100	110	110	85	79
	Minimum	61	34	65	[illegible]	46	48	69	72
	No. Samples	6	8	8	7	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Chlorides (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	24	31	25	14
8-31	2.67 to 2.94	-	30	-	27	-	-	-	-
9-7	2.55 to 2.94	36	-	35	40	40	43	25	25
9-14	2.40 to 3.00	-	27	20	21	20	49	27	11
9-21	1.93 to 2.63	39	130	40	47	47	46	35	12
10-5	1.87 to 2.69	-	23	27	27	24	28	27	9
10-12	1.50 to 2.17	35	38	44	48	37	45	30	12
10-19	1.45 to 2.17	64	63	65	64	62	65	26	10
10-29	Old Channel	8	10	23	-	-	-	30	22
11-8	0.87 to 1.46	40	41	77	69	40	41	17	11
	Average	37	45	41	43	37	44	27	14
	Maximum	64	130	77	69	62	65	35	25
	Minimum	8	10	20	21	20	28	17	9
	No. Samples	6	8	8	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Phenol (µg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	94	11	15	10
8-31	2.67 to 2.94	-	10	41	51	-	-	-	-
9-7	2.55 to 2.94	9	-	12	12	12	8	4	8
9-14	2.40 to 3.00	-	3	4	5	1	2	4	3
9-21	1.93 to 2.63	15	16	13	11	18	9	19	19
10-5	1.87 to 2.69	-	15	15	13	17	23	16	16
10-12	1.50 to 2.17	245	110	80	14	220	21	24	22
10-19	1.45 to 2.17	15	14	16	13	19	16	18	17
10-29	Old Channel	8	12	17	-	-	-	16	17
11-8	0.87 to 1.46	22	13	24	19	27	9	13	8
	Average	52	24	25	17	51	12	14	13
	Maximum	245	110	80	51	220	23	24	22
	Minimum	8	3	4	5	1	2	4	3
	No. Samples	6	8	9	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Dissolved Oxygen (mg/1)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	1.8	2.9	7.4	7.9
8-31	2.67 to 2.94	-	1.5	-	1.9	-	-	-	-
9-7	2.55 to 2.94	1.3	-	2.9	2.3	2.3	2.2	8.1	8.0
9-14	2.40 to 3.00	-	1.9	3.9	3.0	3.1	1.7	7.9	8.6
9-21	1.93 to 2.63	4.7	0.1	0.2	.3	0.2	.2	7.7	8.2
10-5	1.87 to 2.69	-	5.4	2.7	2.4	5.2	1.8	9.9	9.7
10-12	1.50 to 2.17	2.0	0.6	0.1	0.1	2.2	0.1	9.1	9.6
10-19	1.45 to 2.17	4.4	2.8	3.6	3.0	4.3	2.8	9.6	10.0
10-29	Old Channel	10.6	10.1	8.1	-	-	-	10.4	10.5
11-8	0.87 to 1.46	7.6	6.8	6.5	9.2	7.7	6.4	11.2	11.5
	Average	5.1	3.7	3.5	2.8	3.4	2.3	9.0	9.3
	Maximum	10.6	10.1	8.1	9.2	7.7	6.4	11.2	11.5
	Minimum	1.3	0.1	0.1	0.1	0.2	0.1	7.4	7.9
	No. Samples	6	8	8	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: BOD (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	3	3	4	4
8-31	2.67 to 2.94	-	4	-	3	-	-	-	-
9-7	2.55 to 2.94	2	-	2	2	2	2	5	4
9-14	2.40 to 3.00	-	16	4	2	3	4	5	4
9-21	1.93 to 2.63	2	7	5	4	4	3	5	9
10-5	1.87 to 2.69	-	13	5	4	4	4	7	4
10-12	1.50 to 2.17	5	5	6	6	4	6	5	4
10-19	1.45 to 2.17	3	11	4	5	4	4	2	3
10-29	Old Channel	3	6	14	-	-	-	4	4
11-8	0.87 to 1.46	2	9	13	16	2	4	5	4
	Average	3	9	7	5	3	4	5	4
	Maximum	5	16	14	16	4	6	7	9
	Minimum	2	4	2	2	2	2	2	3
	No. Samples	6	8	8	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: COD (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	10	17	21	27
8-31	2.67 to 2.94	-	24	-	11	-	-	-	-
9-7	2.55 to 2.94	-	-	-	-	-	-	-	-
9-14	2.40 to 3.00	-	110	15	9	18	18	18	13
9-21	1.93 to 2.63	19	58	27	23	31	23	31	36
10-5	1.87 to 2.69	-	67	32	20	22	24	24	8
10-12	1.50 to 2.17	20	140	42	38	24	28	16	16
10-19	1.45 to 2.17	34	28	52	44	36	40	4	<1
10-29	Old Channel	6	35	61	-	-	-	22	14
11-8	0.87 to 1.46	19	130	58	56	19	33	25	8
	Average	20	74	41	29	23	26	20	15
	Maximum	34	140	61	56	36	40	31	36
	Minimum	6	24	15	9	10	17	4	<1
	No. Samples	5	8	7	7	7	7	8	8

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Total Phosphate (as PO_4) (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	.64	.55	.28	.60
8-31	2.67 to 2.94	-	.57	-	-	-	-	-	-
9-7	2.55 to 2.94	.38	-	.45	.34	.34	.27	.40	.51
9-14	2.40 to 3.00	-	4.9	.95	2.1	.91	2.7	.28	.38
9-21	1.93 to 2.63	.26	1.7	.67	.40	.61	.50	.24	.65
10-5	1.87 to 2.69	-	1.9	1.2	.92	1.3	.94	.32	.61
10-12	1.50 to 2.17	.67	.24	1.5	1.1	.55	1.2	.33	.66
10-19	1.45 to 2.17	.88	2.6	1.0	1.4	1.0	1.3	.35	.29
10-29	Old Channel	.17	.82	.55	-	-	-	.45	.71
11-8	0.87 to 1.46	1.2	3.0	2.2	.51	.49	4.2	.97	.75
	Average	.59	2.0	1.1	.97	.74	1.5	.40	.57
	Maximum	1.2	4.9	2.2	2.1	1.3	4.2	.97	.75
	Minimum	.17	.24	.45	.34	.34	.27	.24	.29
	No. Samples	6	8	8	7	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Total Soluble Phosphate (as PO_4)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	.28	.22	.12	.20
8-31	2.67 to 2.94	-	.06	-	-	-	-	-	-
9-7	2.55 to 2.94	.06	-	.11	.07	.07	.15	.32	.41
9-14	2.40 to 3.00	-	.08	.50	1.6	.49	2.3	.17	.23
9-21	1.93 to 2.63	.17	.13	.15	.19	.06	.15	.15	.27
10-5	1.87 to 2.69	-	.29	.14	.21	.22	.28	.30	.50
10-12	1.50 to 2.17	.17	.23	.17	.22	.18	.24	.12	.36
10-19	1.45 to 2.17	.39	.31	.34	.53	.31	.29	.27	.27
10-29	Old Channel	.09	.15	.33	-	-	-	.43	.30
11-8	0.87 to 1.46	.06	.06	.19	.47	.39	.30	.26	.27
	Average	.16	.16	.24	.47	.25	.49	.24	.31
	Maximum	.39	.31	.50	1.6	.49	2.3	.43	.50
	Minimum	.06	.06	.11	.07	.06	.15	.12	.20
	No. Samples	6	8	8	7	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Nitrate-N (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	.3	.3	.3	.3
8-31	2.67 to 2.94	-	.5	-	.3	-	-	-	-
9-7	2.55 to 2.94	<.1	-	<.1	.1	.1	<.1	.1	.1
9-14	2.40 to 3.00	-	1.9	.4	.4	.4	.3	.4	.4
9-21	1.93 to 2.63	.3	.3	.2	.3	.2	.1	.6	.4
10-5	1.87 to 2.69	-	.8	.5	.4	.6	.4	.3	.3
10-12	1.50 to 2.17	.4	.9	.6	.3	.5	.5	.3	.3
10-19	1.45 to 2.17	2.5	2.2	2.4	2.2	2.7	2.5	.4	.4
10-29	Old Channel	.2	.3	.2	-	-	-	.2	.1
11-8	0.87 to 1.46	1.4	1.3	1.2	.7	1.7	1.8	.6	.6
	Average	.8	1.0	.7	.6	.8	.8	.4	.3
	Maximum	2.5	2.2	2.4	2.2	2.7	2.5	.6	.6
	Minimum	<.1	.3	<.1	.1	.1	<.1	.1	.1
	No. Samples	6	8	8	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Nitrite-N (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	.03	.03	<.01	<.01
8-31	2.67 to 2.94	-	.05	-	.06	-	-	-	-
9-7	2.55 to 2.94	.02	-	.02	.02	.02	.02	.01	.01
9-14	2.40 to 3.00	-	.02	.01	.01	.01	.01	.01	.01
9-21	1.93 to 2.63	.02	.04	.09	.04	.03	.05	.01	.02
10-5	1.87 to 2.69	-	.01	.02	.02	.02	.02	.01	.01
10-12	1.50 to 2.17	.04	.04	.09	.10	.04	.11	.02	.01
10-19	1.45 to 2.17	.05	.04	.05	.05	.05	.05	.02	.01
10-29	Old Channel	.01	.01	.01	-	-	-	.02	.02
11-8	0.87 to 1.46	.02	.02	.02	.01	.02	.03	.01	.01
	Average	.03	.03	.04	.04	.03	.04	.01	.01
	Maximum	.05	.05	.09	.10	.05	.11	.02	.02
	Minimum	.01	.01	.01	.01	.01	.01	<.01	<.01
	No. Samples	6	8	8	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Ammonia-N (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	1.90	1.50	.12	.42
8-31	2.67 to 2.94	-	-	-	-	-	-	-	-
9-7	2.55 to 2.94	.83	-	1.30	-	1.20	1.10	.43	.30
9-14	2.40 to 3.00	-	.94	1.20	1.20	1.10	1.30	.06	.41
9-21	1.93 to 2.63	.58	1.70	1.50	1.80	1.20	1.30	.32	.72
10-5	1.87 to 2.69	-	.56	.85	.84	.64	.77	.46	.32
10-12	1.50 to 2.17	1.60	1.70	2.40	1.60	1.40	2.00	.34	.45
10-19	1.45 to 2.17	.69	.51	.76	.65	.80	.77	.40	.18
10-29	Old Channel	.12	.36	.10	-	-	-	.36	.45
11-8	0.87 to 1.46	.83	1.10	.97	.55	.99	1.00	.54	.37
	Average	.78	.98	1.10	1.10	1.20	1.20	.34	.40
	Maximum	1.60	1.70	2.40	1.80	1.90	2.00	.54	.72
	Minimum	.12	.36	.10	.55	.64	.77	.06	.18
	No. Samples	6	7	8	6	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Organic-N (mg/1)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	.14	.14	.23	-
8-31	2.67 to 2.94	-	-	-	-	-	-	-	-
9-7	2.55 to 2.94	.12	-	.08	-	.07	<.05	.05	.05
9-14	2.40 to 3.00	-	<.05	.18	.05	.14	.10	<.05	.08
9-21	1.93 to 2.63	.09	<.05	.09	.10	<.05	.11	.14	.15
10-5	1.87 to 2.69	-	.10	.11	.17	.11	.06	.11	.10
10-12	1.50 to 2.17	.34	<.05	.35	.16	.09	.13	.58	.32
10-19	1.45 to 2.17	.12	.18	.18	.19	.12	.15	.16	.10
10-29	Old Channel	<.05	.24	.15	-	-	-	.11	.10
11-8	0.87 to 1.46	.06	.41	.10	.08	.08	.08	.18	.09
	Average	.13	.15	.16	.13	.10	.10	.18	.12
	Maximum	.34	.41	.35	.19	.14	.15	.58	.32
	Minimum	<.05	<.05	.08	.05	<.05	<.05	<.05	.05
	No. Samples	6	7	8	6	8	8	9	8

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Total Coliform (MF/100 ml)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	21,000	30,000	30,000	20,000
8-31	2.67 to 2.94	-	61,000	58,000	33,000	-	-	-	-
9-7	2.55 to 2.94	1,000	-	3,800	2,900	2,900	6,700	4,500	500
9-14	2.40 to 3.00	-	1,800	1,200	8,000	2,200	42,000	50,000	510,000
9-21	1.93 to 2.63	900	3,800	8,300	14,000	1,900	17,000	220,000	140,000
10-5	1.87 to 2.69	-	4,000	7,400	33,000	3,400	120,000	26,000	270
10-12	1.50 to 2.17	>20,000	140,000	73,000	360,000	>19,000	91,000	7,500	400
10-19	1.45 to 2.17	540,000	500,000	470,000	420,000	510,000	420,000	39,000	3,000
10-29	Old Channel	80,000	110,000	110,000	-	-	-	57,000	3,400
11-8	0.87 to 1.46	390,000	100,000	830,000	360,000	34,000	86,000	77,000	7,400
	Median	50,000	81,000	58,000	33,000	11,200	64,000	39,000	3,400
	Maximum	540,000	500,000	830,000	420,000	510,000	420,000	220,000	510,000
	Minimum	900	1,800	1,200	2,900	1,900	6,700	4,500	270
	No. Samples	6	8	9	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Fecal Coliform (MF/100 ml)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	930	2,600	1,100	440
8-31	2.67 to 2.94	-	3,600	2,200	1,300	-	-	-	-
9-7	2.55 to 2.94	<100	-	200	400	400	900	100	<100
9-14	2.40 to 3.00	-	70	100	650	280	12,000	4,100	56,000
9-21	1.93 to 2.63	110	480	900	1,800	50	4,700	21,000	710
10-5	1.87 to 2.69	-	320	750	1,600	340	7,700	530	10
10-12	1.50 to 2.17	3,000	4,400	5,200	14,000	2,800	6,300	400	<100
10-19	1.45 to 2.17	22,000	39,000	17,000	25,000	37,000	32,000	2,400	170
10-29	Old Channel	5,000	6,900	8,600	-	-	-	3,400	1,900
11-8	0.87 to 1.46	1,600	4,200	56,000	25,000	1,800	3,300	6,600	80
	Median	2,300	3,900	2,200	1,700	670	5,500	2,400	170
	Maximum	22,000	39,000	56,000	25,000	37,000	32,000	21,000	56,000
	Minimum	<100	70	100	400	50	900	100	10
	No. Samples	6	8	9	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Total Solids (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	230	250	220	170
8-31	2.67 to 2.94	-	330	-	290	-	-	-	-
9-7	2.55 to 2.94	280	-	260	270	270	280	230	200
9-14	2.40 to 3.00	-	680	270	240	240	300	230	180
9-21	1.93 to 2.63	240	630	320	300	320	290	240	180
10-5	1.87 to 2.69	-	400	290	210	270	260	220	160
10-12	1.50 to 2.17	250	450	340	330	260	330	220	150
10-19	1.45 to 2.17	420	430	460	450	410	450	200	160
10-29	Old Channel	170	390	310	-	-	-	250	200
11-8	0.87 to 1.46	290	720	400	380	300	370	-	-
	Average	280	500	330	310	290	320	230	180
	Maximum	420	720	460	450	410	450	250	200
	Minimum	170	330	260	210	230	250	200	150
	No. Samples	6	8	8	8	8	8	8	8

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Dissolved Solids (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	210	230	180	140
8-31	2.67 to 2.94	-	270	-	260	-	-	-	-
9-7	2.55 to 2.94	260	-	240	260	260	280	200	190
9-14	2.40 to 3.00	-	330	240	210	210	260	220	180
9-21	1.93 to 2.63	240	470	270	280	260	270	230	160
10-5	1.87 to 2.69	-	190	210	170	200	230	190	140
10-12	1.50 to 2.17	210	240	240	270	230	260	200	140
10-19	1.45 to 2.17	350	160	350	320	320	430	180	140
10-29	Old Channel	150	160	210	-	-	-	220	170
11-8	0.87 to 1.46	280	720	340	340	280	300	-	-
	Average	250	320	260	260	250	280	200	160
	Maximum	350	720	350	340	320	430	230	190
	Minimum	150	160	210	170	200	230	180	140
	No. Samples	6	8	8	8	8	8	8	8

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Suspended Solids (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	21	15	42	31
8-31	2.67 to 2.94	-	62	-	28	-	-	-	-
9-7	2.55 to 2.94	18	-	17	10	10	2	26	12
9-14	2.40 to 3.00	-	350	29	27	34	34	6	7
9-21	1.93 to 2.63	8	160	47	21	56	24	12	21
10-5	1.87 to 2.69	-	210	81	43	78	30	21	17
10-12	1.50 to 2.17	35	210	95	60	31	65	20	12
10-19	1.45 to 2.17	67	270	120	120	90	14	24	21
10-29	Old Channel	23	230	93	-	-	-	34	34
11-8	0.87 to 1.46	13	450	60	38	21	72	10	11
	Average	27	240	68	43	43	32	22	18
	Maximum	67	450	120	120	90	72	42	34
	Minimum	8	62	17	10	10	2	6	7
	No. Samples	6	8	8	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Total Volatile Solids (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	84	88	71	52
8-31	2.67 to 2.94	-	98	85	-	-	-	-	-
9-7	2.55 to 2.94	84	-	71	-	78	64	71	71
9-14	2.40 to 3.00	-	160	120	86	60	81	110	67
9-21	1.93 to 2.63	89	230	120	110	110	110	120	78
10-5	1.87 to 2.69	-	100	74	87	86	73	90	60
10-12	1.50 to 2.17	72	110	91	100	88	92	83	49
10-19	1.45 to 2.17	86	87	120	110	78	100	75	-
10-29	Old Channel	57	92	110	-	-	-	96	56
11-8	0.87 to 1.46	130	350	290	160	100	170	-	-
	Average	86	150	110	110	86	97	90	62
	Maximum	130	350	290	160	110	170	120	78
	Minimum	57	87	74	86	60	64	71	49
	No. Samples	6	8	9	6	8	8	8	7

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Volatile Suspended Solids (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	4	4	5	6
8-31	2.67 to 2.94	-	13	10	10	-	-	-	-
9-7	2.55 to 2.94	8	-	2	3	3	1	4	2
9-14	2.40 to 3.00	-	52	4	8	4	6	1	2
9-21	1.93 to 2.63	4	27	10	7	11	9	7	12
10-5	1.87 to 2.69	-	34	13	10	11	5	7	5
10-12	1.50 to 2.17	4	27	10	6	1	8	5	2
10-19	1.45 to 2.17	10	41	24	14	19	12	1	3
10-29	Old Channel	2	28	13	-	-	-	1	1
11-8	0.87 to 1.46	3	82	14	11	2	13	5	1
	Average	5	38	11	9	7	7	4	4
	Maximum	10	82	24	14	19	13	7	12
	Minimum	2	13	2	3	1	1	1	1
	No. Samples	6	8	9	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Iron (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	1.7	2.0	1.5	1.0
8-31	2.67 to 2.94	-	8.8	-	5.0	-	-	-	-
9-7	2.55 to 2.94	5.7	-	4.2	3.5	3.5	2.8	1.0	2.4
9-14	2.40 to 3.00	-	55	5.5	3.1	4.6	2.9	.73	.71
9-21	1.93 to 2.63	.95	14	3.5	1.3	4.5	1.8	.22	.82
10-5	1.87 to 2.69	-	12	4.7	4.6	6.1	2.1	.52	.42
10-12	1.50 to 2.17	3.7	18	11	7.6	3.5	6.8	.54	.78
10-19	1.45 to 2.17	3.3	7.1	8.1	9.6	5.1	10	.61	.10
10-29	Old Channel	.88	9.0	2.2	-	-	-	1.2	.82
11-8	0.87 to 1.46	2.6	34	5.7	1.4	3.3	6.6	.71	.41
	Average	2.9	20	5.6	4.5	4.0	4.4	.78	.83
	Maximum	5.7	55	11	9.6	6.1	10	1.5	2.4
	Minimum	.88	7.1	2.2	1.3	1.7	1.8	.22	.10
	No. Samples	6	8	8	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Oil & Grease (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	-	-	-	-
8-31	2.67 to 2.94	-	-	-	-	-	-	-	-
9-7[a]	2.55 to 2.94	-	-	-	-	-	-	-	-
9-14	2.40 to 3.00	-	29	12	12	4	16	5	7
9-21[b]	1.93 to 2.63	7	10	35	6	7	16	36	15
10-5	1.87 to 2.69	-	7	3	4	3	3	4	4
10-12	1.50 to 2.17	5	5	4	4	4	4	2	3
10-19	1.45 to 2.17	3	3	4	4	5	5	4	5
10-29	Old Channel	2	3	2	-	-	-	3	2
11-8	0.87 to 1.46	-	-	-	-	-	-	-	-
	Average	4	10	10	6	5	9	9	6
	Maximum	7	29	35	12	7	16	36	15
	Minimum	2	3	2	4	3	3	2	2
	No. Samples	4	6	6	5	5	5	6	6

a - Extensive oil slick covering the Rouge River
b - Heavy oil slick between NYC RR (MP 1.47) and Wabash RR (MP 1.87) bridges.

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Turbidity (Jackson Units)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	35	30	35	30
8-31	2.67 to 2.94	-	50	-	35	-	-	-	-
9-7	2.55 to 2.94	35	-	35	25	25	<25	<25	<25
9-14	2.40 to 3.00	-	500	70	40	55	45	25	<25
9-21	1.93 to 2.63	<25	110	70	<25	55	30	<25	<25
10-5	1.87 to 2.69	-	180	110	70	120	45	<25	<25
10-12	1.50 to 2.17	60	220	160	90	65	100	<25	<25
10-19	1.45 to 2.17	130	280	220	210	150	210	<25	<25
10-29	Old Channel	25	160	85	-	-	-	40	25
11-8	0.87 to 1.46	<25	130	35	<25	<25	70	<25	<25
	Average	50	200	100	65	66	69	28	26
	Maximum	130	500	220	210	150	210	40	30
	Minimum	<25	50	35	<25	<25	<25	<25	<25
	No. Samples	6	8	8	8	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Secchi Disc (inches)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	18	18	30	18
8-31	2.67 to 2.94	-	-	-	-	-	-	-	-
9-7	2.55 to 2.94	18	-	17	-	16	18	30	30
9-14	2.40 to 3.00	-	-	7	9	7	12	28	24
9-21	1.93 to 2.63	24	3	7	16	9	11	28	18
10-5	1.87 to 2.69	-	6	9	12	9	12	24	25
10-12	1.50 to 2.17	11	4	6	6	11	6	23	26
10-19	1.45 to 2.17	7	3	6	6	6	6	20	40
10-29	Old Channel	18	3	8	-	-	-	14	16
11-8	0.97 to 1.46	14	3	6	13	12	5	14	24
	Average	15	4	8	10	11	11	23	25
	Maximum	24	6	17	16	18	18	30	40
	Minimum	7	3	6	6	6	5	14	16
	No. Samples	6	6	8	6	8	8	9	9

TABLE 6 (cont'd)
DREDGING OPERATION SAMPLING RESULTS
PARAMETER: Sulfate (mg/l)

Date 1967	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	DT 19.0 R139	DT 19.0 R142
8-24	None	-	-	-	-	55	57	18	16
9-7	2.55 to 2.94	49	-	-	-	39	40	17	17
9-14	2.40 to 3.00	-	39	31	30	32	40	19	17
9-21	1.93 to 2.63	29	36	30	34	38	32	20	19
10-5	1.87 to 2.69	-	35	32	32	26	31	18	16
10-12	1.50 to 2.17	28	28	31	37	27	33	18	15
10-19	1.45 to 2.17	49	50	-	52	48	50	20	17
10-29	Old Channel	12	16	14	-	-	-	18	13
11-8	0.87 to 1.46	56	56	45	34	54	48	22	18
	Average	37	37	31	37	40	41	19	16
	Maximum	56	56	45	52	55	57	22	19
	Minimum	12	16	14	30	26	31	17	13
	No. Samples	6	7	6	6	8	8	9	9

Transparency and Dissolved Oxygen Measurements

On three occasions, special field studies were conducted in the vicinity of the dredging operation. Before the arrival of the dredge the field crew recorded transparency (secchi disc, inches) and dissolved oxygen readings every 300 feet along the estimated path of the dredging operation. When the HOFFMAN returned to the Rouge, the FWPCA boat followed the dredge at a distance of approximately 100 feet. Transparency and dissolved oxygen values, now under the direct influence of the dredging operation, were recorded every 300 feet as before. The results of the survey (pre-dredging and during dredging) for September 18, 1967, is shown in Figure 4 . Surveys on October 2 and November 9 showed similar transparency results.

The results of all three surveys showed that the average transparency before dredging was slightly greater than the transparency during the dredging operation with no overflow. After overflow occurred substantial decreases in transparency were noted. The average secchi disc readings during the three phases are shown in Figure 5 .

Measurements of dissolved oxygen were made simultaneously with the secchi disc readings. The results in Figure 5 show no significant immediate change in dissolved oxygen level as a result of the dredging operation.

The transparency and dissolved oxygen were also measured at time intervals at a particular point on the dredging path. Significant decreases in transparency were noted when the overflowing dredge passed. The transparency of the water returned to its pre-dredging value after varied time periods. (See Figure 6). The dissolved oxygen levels declined after the dredge passed as shown in Figure 6 .

TRANSPARENCY MEASUREMENTS ALONG DREDGING PATH

SEPTEMBER 18, 1967

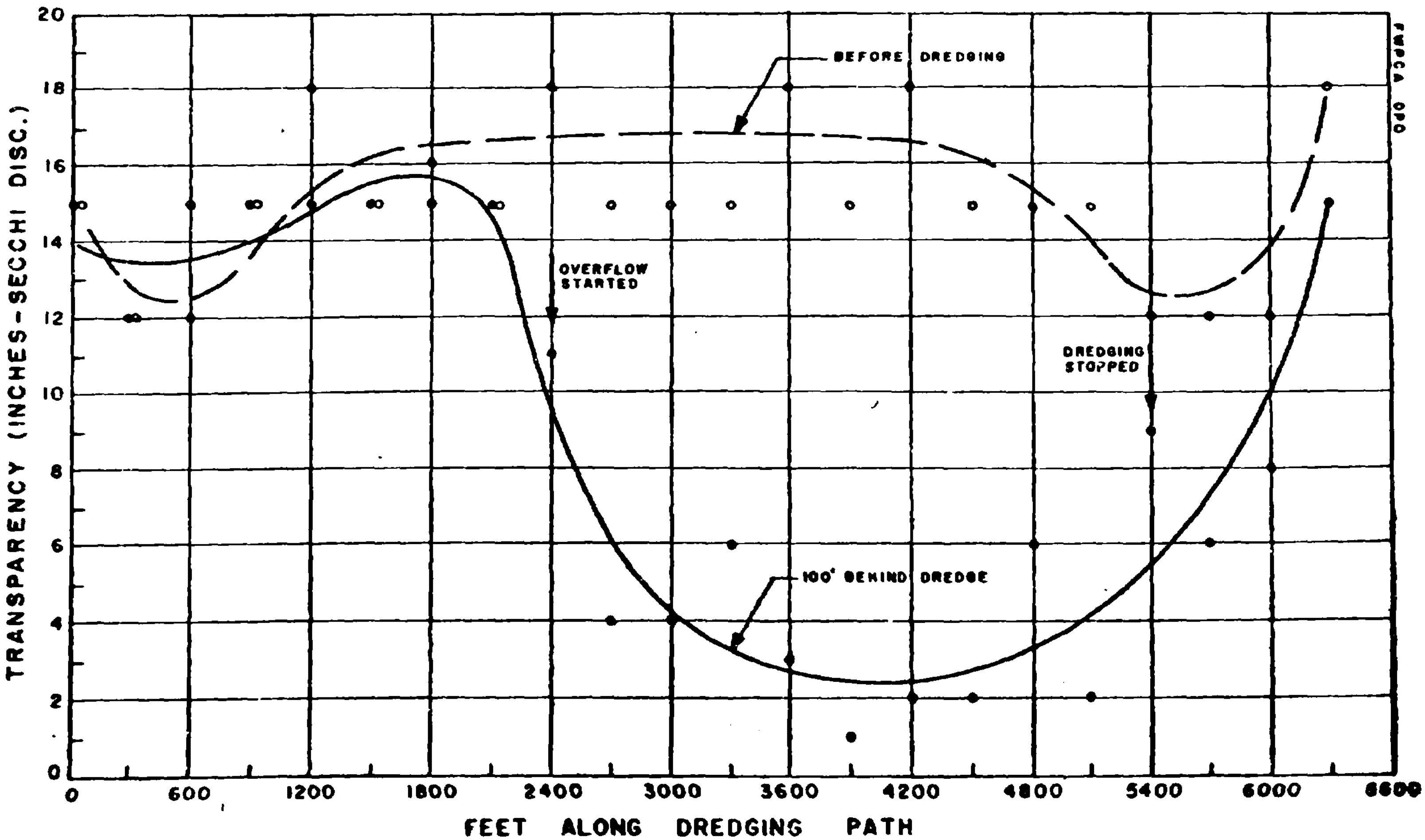
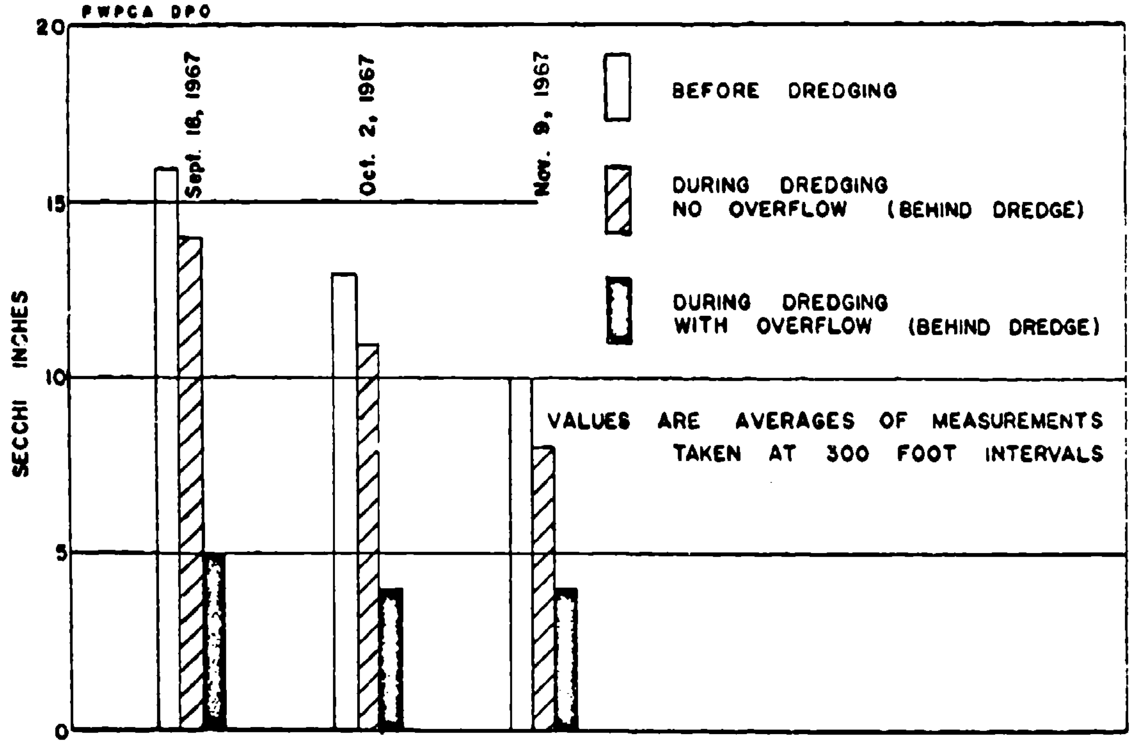
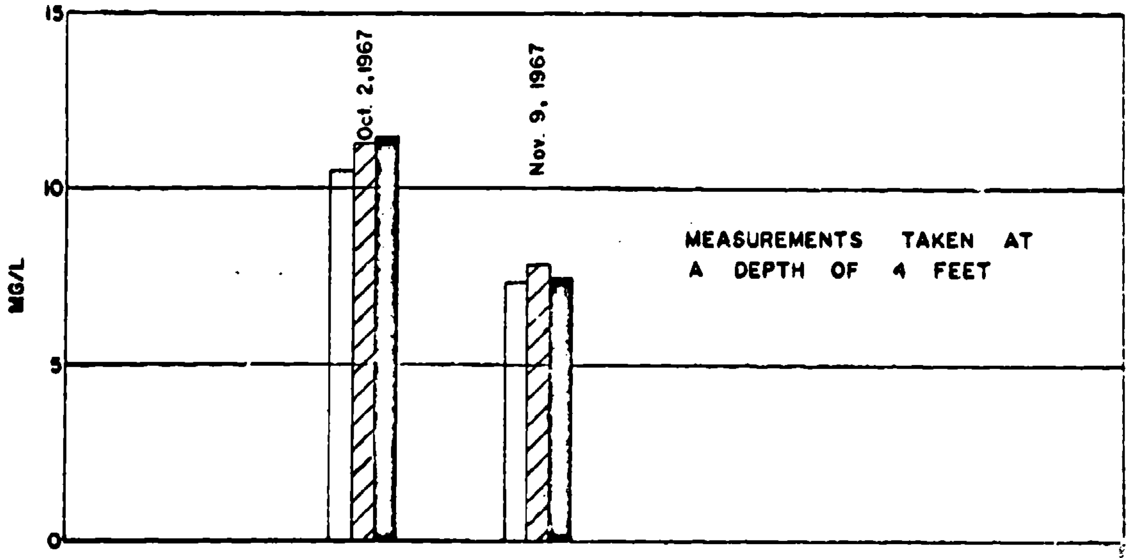


FIGURE 6

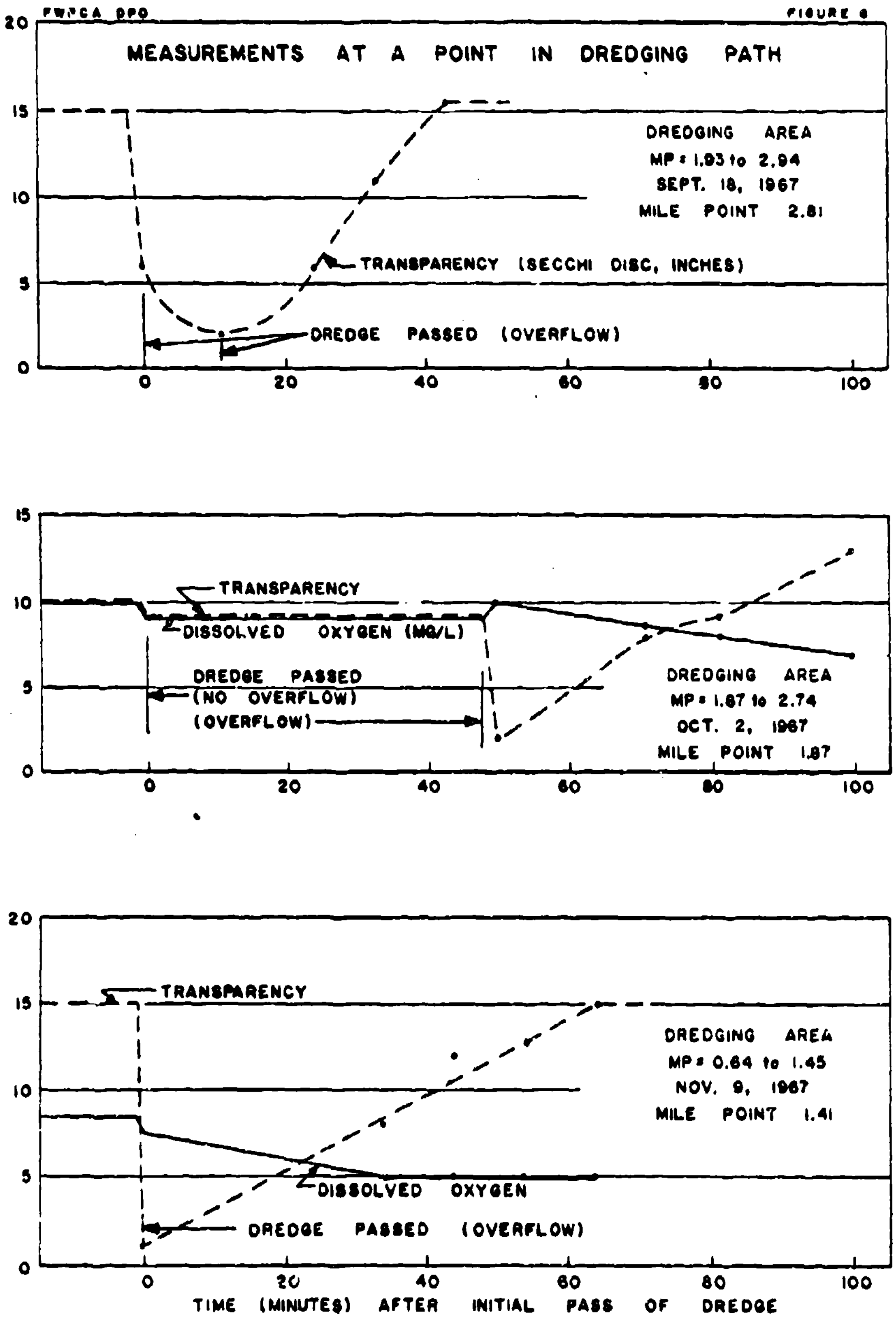
TRANSPARENCY AND DISSOLVED OXYGEN MEASUREMENTS ALONG DREDGING PATH



AVERAGE TRANSPARENCY



AVERAGE DISSOLVED OXYGEN


FWPCA DPO
FIGURE 6
MEASUREMENTS AT A POINT IN DREDGING PATH
DREDGING AREA
MP = 1.93 to 2.94
SEPT. 18, 1967
MILE POINT 2.81
TRANSPARENCY (SECCHI DISC, INCHES)
DREDGE PASSED (OVERFLOW)
TRANSPARENCY
DISSOLVED OXYGEN (MG/L)
DREDGE PASSED
(NO OVERFLOW)
(OVERFLOW)
DREDGING AREA
MP = 1.87 to 2.74
OCT. 2, 1967
MILE POINT 1.87
TRANSPARENCY
DREDGING AREA
MP = 0.64 to 1.45
NOV. 9, 1967
MILE POINT 1.41
DISSOLVED OXYGEN
DREDGE PASSED (OVERFLOW)
TIME (MINUTES) AFTER INITIAL PASS OF DREDGE

Observations

The most severe pollution caused by the dredging operation appeared to occur during the overflow of the hopper bins. At this time, the dredge left a trail of turbidity and surface oil often extending to 150 feet in width. The dredging operation prior to overflow caused minor disturbances observable at the surface from the operation of the drags. Bubbles were observed rising to the surface occasionally bringing up a slight oil film. The bubbles were probably gases released from the anaerobic organic decomposition in the bottom material. However, the propeller action of not only the HOFFMAN but also passing freighters was observed to stir up the bottom sediments to create turbid areas.

No leakage was observed while the dredge was in transit to Grassy Island and no significant leakage occurred at the inflow hookup during the unloading operation.

B. Dumping Grounds - Grassy Island

Effect of Dumping Ground on Detroit River

A water quality study was made of the Detroit River immediately downstream from Grassy Island. Three stations (R37, R41, and R43; 600, 1100, and 2300 feet from U.S. shore, respectively) on range DT 14.6 (less than 3/4 mile south of Grassy Island) were sampled at mid-depth weekly to detect changes in water quality during the period of the dumping operation. The results of the analysis of the samples are shown in Table 7. The City of Wyandotte water intake is also located south of Grassy Island as shown in Figure 7. The results of the routine analysis of this city's raw water before treatment and distribution are shown in Table 8.

Seepage Through Dikes

Seven wells were installed at points along the circumference of the dike to determine the amount of seepage through the dike into the Detroit River. The well holes were hand drilled into the dike the depth required to reach the water table. A six-inch casing with a well screen (approximately 3 feet in length), attached at the lower end, was then dropped into the hole. The hole surrounding the pipe was then backfilled and the casings were covered with a threaded metal cap to prevent contamination of the well. Each well was pumped the day before samples were to be collected. On the sampling day, the coliform samples were first collected with a J.Z.bacteriological sampler and then the chemical samples were collected with a Kemmerer depth sampling device. A surface sample was also collected from the Grassy Island pond at the point as shown on Figure 7. The results of the analyses of well and pond samples are shown in Table 7.

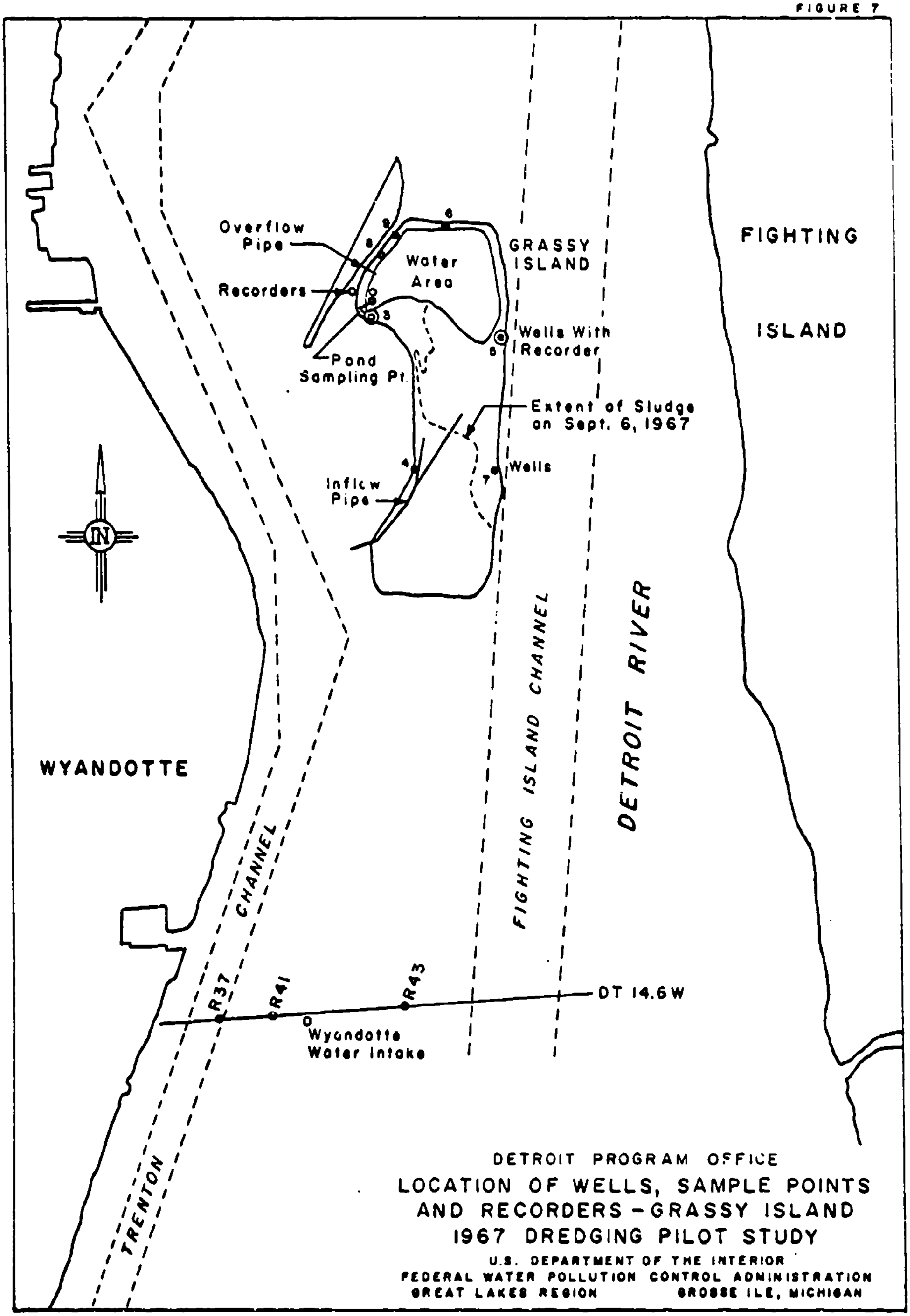


FIGURE 7
Overflow Pipe
Recorders
Water Area
Pond Sampling Pt.
GRASSY ISLAND
Wells With Recorder
Extent of Sludge on Sept. 6, 1967
Wells
Inflow Pipe
FIGHTING ISLAND
N
WYANDOTTE
FIGHTING ISLAND CHANNEL
DETROIT RIVER
TRENTON CHANNEL
R37
R41
R43
DT 14.6W
Wyandotte Water Intake
DETROIT PROGRAM OFFICE
LOCATION OF WELLS, SAMPLE POINTS AND RECORDERS - GRASSY ISLAND
1967 DREDGING PILOT STUDY
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION
GROSSE ILE, MICHIGAN

FWPCA, DPO

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Temperature (°C)

Date	Pond	Wells 3	4	5	6	7	8	9	DT 14.6 R37	R41	R43
9-6	-	-	-	-	-	-	-	-	19.5	19.5	19.5
9-13	-	15.0	15.0	15.0	17.0	15.0	16.0	15.0	19.0	19.0	18.5
9-20	20.0	16.5	15.0	16.0	18.5	17.0	17.0	17.5	21.0	21.0	20.5
10-3	-	-	-	-	-	-	-	-	13.5	14.0	13.0
10-4	-	15.5	-	16.0	16.0	16.0	15.0	16.0	14.0	14.0	14.0
10-11	13.0	14.0	13.0	14.0	14.0	13.5	13.0	13.0	13.0	12.5	12.5
10-18	11.0	13.5	-	13.0	-	13.0	11.5	12.5	13.0	13.0	13.0
10-25	-	-	-	-	-	-	-	-	10.5	10.5	10.5
10-26	-	-	-	-	-	-	-	-	10.0	9.5	9.5
11-1	10.0	13.0	13.0	13.0	-	13.0	11.0	12.0	-	-	-
11-7	3.5	11.5	11.0	11.0	-	10.0	7.5	10.0	7.0	6.5	6.0
11-27	1.0	-	-	-	-	-	-	-	-	1.5	2.0
11-28	-	-	-	-	-	-	-	-	-	2.5	2.5
11-29	-	-	-	-	-	-	-	-	-	2.0	2.0
Average	10.0	14.0	13.5	14.0	16.5	14.0	13.0	13.5	14.0	11.0	11.0
Maximum	20.0	16.5	15.0	16.0	18.5	17.0	17.0	17.5	21.0	21.0	21.5
Minimum	1.0	11.5	11.0	11.0	14.0	10.0	7.5	10.0	7.C	1.5	2.0
No. Samples	6	7	5	7	4	7	7	7	10	13	13

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: pH (standard units)

FWPCA, DPO

Date	Pond	Wells 3	Wells 4	Wells 5	Wells 6	Wells 7	Wells 8	Wells 9	DT 14.6 R37	DT 14.6 R41	DT 14.6 R43
9-6	-	-	-	-	-	-	-	-	7.6	7.8	8.0
9-13	-	7.0	7.4	7.0	7.4	7.0	7.0	7.1	7.9	8.0	7.9
9-20	6.9	6.8	7.6	7.2	7.3	6.8	6.8	7.0	7.6	7.9	8.0
10-3	-	-	-	-	-	-	-	-	8.0	8.2	8.1
10-4	-	7.0	-	7.4	7.8	7.0	7.0	7.4	8.0	8.1	8.2
10-11	7.8	7.4	7.8	6.9	7.7	6.5	7.3	6.4	8.0	8.0	8.1
10-18	7.7	7.4	-	6.9	-	7.4	7.1	7.4	7.8	8.0	8.0
10-25	-	-	-	-	-	-	-	-	8.0	8.2	8.2
10-26	-	-	-	-	-	-	-	-	7.9	8.0	8.2
11-1	7.6	7.1	7.8	7.5	-	6.8	7.2	7.2	-	-	-
11-7	8.2	8.0	7.8	8.2	-	7.8	8.1	7.9	8.2	8.3	8.4
11-27	8.1	-	-	-	-	-	-	-	-	8.1	8.2
11-28	-	-	-	-	-	-	-	-	-	8.1	8.1
11-29	-	-	-	-	-	-	-	-	-	8.0	8.2
Average	7.7	7.2	7.7	7.3	7.6	7.0	7.2	7.2	7.9	8.1	8.1
Maximum	8.2	8.0	7.8	8.2	7.8	7.8	8.1	7.9	8.2	8.3	8.4
Minimum	6.9	6.8	7.4	6.9	7.3	6.5	6.8	6.4	7.6	7.8	7.9
No. Samples	6	7	5	7	4	7	7	7	10	13	13

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA

FWPCA, DPO

PARAMETER: Conductivity (umhos/cm)

Date	Pond	Wells 3	Wells 4	Wells 5	Wells 6	Wells 7	Wells 8	Wells 9	DT 14.6 R37	DT 14.6 R41	DT 14.6 R43
9-6	-	-	-	-	-	-	-	-	-	-	-
9-13	-	1100	3500	1300	2300	4000	2000	1300	250	240	240
9-20	1100	2200	2800	1300	2200	4000	1800	1200	250	240	230
10-3	-	-	-	-	-	-	-	-	230	210	210
10-4	-	2400	-	1700	2200	3700	1500	1100	240	220	220
10-11	1100	2800	2300	1600	2300	3700	2000	1300	250	230	220
10-18	960	2600	-	1600	-	3500	1600	1100	290	230	210
10-25	-	-	-	-	-	-	-	-	260	220	220
10-26	-	-	-	-	-	-	-	-	280	230	220
11-1	1000	2600	2900	1500	-	3700	1600	1300	-	-	-
11-7	950	2500	2900	1700	-	3500	1600	1200	300	210	220
11-27	1000	-	-	-	-	-	-	-	-	220	210
11-28	-	-	-	-	-	-	-	-	-	210	210
11-29	-	-	-	-	-	-	-	-	-	220	200
Average	1000	2400	3000	1500	2200	3700	1700	1200	260	220	220
Maximum	1100	2800	3500	1700	2300	4000	2000	1300	300	240	240
Minimum	950	1100	2800	1300	2200	3500	1500	1100	240	210	200
No. Samples	6	7	5	7	4	7	7	7	9	12	12

FWPCA, DPO

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Alkalinity (mg/1 as $CaCO_3$)

Date	Pond	Wells							DT 14.6		
		3	4	5	6	7	8	9	R37	R41	R43
9-6	-	-	-	-	-	-	-	-	42	79	77
9-13	-	250	860	590	430	330	270	660	77	77	83
9-20	260	380	890	530	400	660	300	270	79	75	79
10-3	-	-	-	-	-	-	-	-	45	73	76
10-4	-	480	-	440	380	650	270	300	79	78	78
10-11	290	440	770	530	390	540	380	380	78	76	75
10-18	260	340	-	510	-	540	230	270	79	75	73
10-25	-	-	-	-	-	-	-	-	80	76	78
10-26	-	-	-	-	-	-	-	-	82	78	76
11-1	290	460	700	550	-	600	310	410	-	-	-
11-7	260	460	670	510	-	520	280	330	82	72	77
11-27	270	-	-	-	-	-	-	-	-	82	78
11-28	-	-	-	-	-	-	-	-	-	77	77
11-29	-	-	-	-	-	-	-	-	-	81	76
Average	270	400	780	520	400	550	290	370	72	77	77
Maximum	290	480	890	590	430	660	380	660	82	82	83
Minimum	260	250	690	440	380	330	230	270	42	72	73
No. Samples	6	7	5	7	4	7	7	7	10	13	13

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TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Chlorides (mg/1)

Date	Pond	Wells 3	Wells 4	Wells 5	Wells 6	Wells 7	Wells 8	Wells 9	DT 14.6 R37	DT 14.6 R41	DT 14.6 R43
9-6	-	-	-	-	-	-	-	-	15	13	20
9-13	-	33	68	66	99	280	66	160	15	12	11
9-20	130	76	61	51	100	250	100	130	13	12	11
10-3	-	-	-	-	-	-	-	-	12	9	10
10-4	-	110	-	84	94	230	140	140	15	11	10
10-11	130	140	57	73	94	210	110	86	15	10	9
10-18	130	120	-	74	-	200	120	110	21	11	9
10-25	-	-	-	-	-	-	-	-	17	10	10
10-26	-	-	-	-	-	-	-	-	21	10	9
11-1	140	140	59	46	-	200	110	88	-	-	-
11-7	120	140	60	79	-	170	110	110	28	9	9
11-27	160	-	-	-	-	-	-	-	-	10	8
11-28	-	-	-	-	-	-	-	-	-	12	10
11-29	-	-	-	-	-	-	-	-	-	12	9
Average	140	110	61	68	97	220	110	120	17	11	10
Maximum	160	140	68	84	100	280	140	160	28	13	11
Minimum	120	33	57	46	94	170	66	86	12	9	8
No. Samples	6	7	5	7	4	7	7	7	10	13	13

FWPCA, DPO

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Phenols (ug/l)

Date	Pond	Wells 3	Wells 4	Wells 5	Wells 6	Wells 7	Wells 8	Wells 9	DT 14.6 R37	DT 14.6 R41	DT 14.6 R43
9-6	-	-	-	-	-	-	-	-	15	24	16
9-13	-	10	10	7	9	7	15	11	6	6	6
9-20	22	10	14	16	8	13	13	12	15	11	6
10-3	-	-	-	-	-	-	-	-	5	7	5
10-4	-	18	-	7	6	9	7	11	9	8	6
10-11	9	13	3	8	7	12	15	14	10	9	9
10-18	12	12	-	9	-	10	8	9	12	9	9
10-25	-	-	-	-	-	-	-	-	12	8	6
10-26	-	-	-	-	-	-	-	-	12	6	5
11-1	13	10	8	10	-	5	8	8	-	-	-
11-7	-	-	-	-	-	-	-	-	-	-	-
11-27	10	-	-	-	-	-	-	-	-	8	5
11-28	-	-	-	-	-	-	-	-	-	4	6
11-29	-	-	-	-	-	-	-	-	-	4	2
Average	13	12	9	10	8	9	11	11	11	9	7
Maximum	22	18	14	16	9	13	15	14	15	24	16
Minimum	9	10	3	7	6	5	7	8	5	4	2
No. Samples	5	6	4	6	4	6	6	6	9	12	12

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Dissolved Oxygen (mg/l)

JPCA, DPO

Date	Pond	Wells 3	4	5	6	7	8	9	DT 14.6 R37	R41	R43
9-6	-	-	-	-	-	-	-	-	-	8.6	8.5
9-13	-	.6	.4	.4	1.1	.8	.1	.9	8.2	8.3	8.7
9-20	< .1	1.2	3.3	.1	.9	.6	.5	1.0	8.2	8.0	8.6
10-3	-	-	-	-	-	-	-	-	-	-	-
10-4	-	.1	-	.6	.8	.4	.6	1.6	9.8	9.8	10.0
10-11	.1	1.2	2.9	.2	.9	1.0	1.1	1.2	9.5	9.5	9.7
10-18	3.5	1.5	-	.8	-	1.2	1.0	2.1	9.5	9.6	9.8
10-25	-	-	-	-	-	-	-	-	10.4	10.5	10.7
10-25	-	-	-	-	-	-	-	-	10.2	10.6	10.7
11-1	1.7	1.5	1.5	.7	-	2.0	1.4	1.7	-	-	-
11-7	5.7	.8	2.1	.2	-	1.2	1.1	.5	10.5	11.3	11.3
11-27	6.0	-	-	-	-	-	-	-	-	12.8	12.6
11-28	-	-	-	-	-	-	-	-	-	12.7	12.9
11-29	-	-	-	-	-	-	-	-	-	12.7	12.6
Average	2.9	1.0	2.0	.4	.9	1.0	.8	1.3	9.5	10.4	10.5
Maximum	6.0	1.5	3.3	.8	1.1	2.0	1.4	2.1	10.5	12.8	12.9
Minimum	< .1	.1	.4	.1	.8	.4	.1	.5	8.2	8.0	8.5
No. Samples	6	7	5	7	4	7	7	7	8	12	12

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: BOD (mg/l)

FWPCA, DPO

Date	Pond	Wells 3	Wells 4	Wells 5	Wells 6	Wells 7	Wells 8	Wells 9	DT 14.6 R37	DT 14.6 R41	DT 14.6 R43
9-6	-	-	-	-	-	-	-	-	4	2	1
9-13	-	8	16	21	5	17	9	10	3	3	3
9-20	42	12	13	26	6	9	14	47	5	4	3
10-3	-	-	-	-	-	-	-	-	4	7	2
10-4	-	13	-	18	5	7	11	73	5	4	3
10-11	17	9	10	11	5	8	9	21	5	3	2
10-18	15	20	-	17	-	10	10	170	4	3	2
10-25	-	-	-	-	-	-	-	-	4	2	2
10-26	-	-	-	-	-	-	-	-	2	2	1
11-1	13	6	4	10	-	4	3	13	-	-	-
11-7	9*	10*	9*	16*	-	4*	6*	45*	5*	4*	2*
11-27	7	-	-	-	-	-	-	-	-	3	2
11-28	-	-	-	-	-	-	-	-	-	2*	3*
11-29	-	-	-	-	-	-	-	-	-	5	3
Average	18	11	10	17	5	8	9	54	4	3	2
Maximum	42	20	16	26	6	17	14	170	5	7	3
Minimum	7	6	4	10	5	4	3	10	2	2	1
No. Samples	6	7	5	7	4	7	7	7	10	13	13

*Estimated

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: COD (mg/1)

FWFCA, DPO

Date	Pond	Wells 3	Wells 4	Wells 5	Wells 6	Wells 7	Wells 8	Wells 9	DT 14.6 R37	DT 14.6 R41	DT 14.6 R43
9-6	-	-	-	-	-	-	-	-			
9-13	-	160	280	96	55	260	250	120	9	7	< 1
9-20	160	180	620	120	54	270	160	210	13	12	13
10-3	-	-	-	-	-	-	-	-	16	8	1
10-4	-	220	-	97	51	240	150	380	8	61	< 1
10-11	130	150	250	88	46	190	540	130	18	12	10
10-18	110	170	-	78	-	160	120	210	24	14	6
10-25	-	-	-	-	-	-	-	-	16	6	6
10-26	-	-	-	-	-	-	-	-	14	10	10
11-1	100	120	370	66	-	170	160	120	-	-	-
11-7	85	170	350	67	-	130	130	140	27	15	2
11-27	84	-	-	-	-	-	-	-	-	15	26
11-28	-	-	-	-	-	-	-	-	-	7	7
11-29	-	-	-	-	-	-	-	-	-	4	4
Average	110	170	370	87	52	200	220	190	16	14	7
Maximum	160	210	620	120	55	270	540	380	27	61	26
Minimum	84	120	250	66	46	130	120	120	8	4	< 1
No. Samples	6	7	5	7	4	7	7	7	9	12	12

FWPCA, DPO

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Total Phosphate (as PO_4) (mg/1)

Date	Pond	Wells 3	Wells 4	Wells 5	Wells 6	Wells 7	Wells 8	Wells 9	DT 14.6 R37	DT 14.6 R41	DT 14.6 R43
9-6	-	-	-	-	-	-	-	-	-	-	-
9-13	-	4.2	.71	3.9	.89	.49	2.3	1.8	.37	.29	.11
9-20	1.9	.63	8.8	1.5	.39	.97	1.1	2.9	.29	.27	.23
10-3	-	-	-	-	-	-	-	-	.60	.55	.32
10-4	-	3.4	-	2.1	2.1	2.3	2.9	9.1	.48	.43	.44
10-11	1.0	.63	2.0	1.3	.37	1.3	4.5	2.0	.39	.33	.14
10-18	1.1	1.7	-	.61	-	1.2	1.6	5.5	.48	.18	.19
10-25	-	-	-	-	-	-	-	-	.52	.55	.44
10-26	-	-	-	-	-	-	-	-	.57	.28	.27
11-1	.51	.64	3.3	.51	-	1.5	1.1	1.9	-	-	-
11-7	.92	.81	.79	.51	-	.56	1.0	1.8	.61	.43	.30
11-27	.30	-	-	-	-	-	-	-	-	.29	.15
11-28	-	-	-	-	-	-	-	-	-	.26	.12
11-29	-	-	-	-	-	-	-	-	-	.30	.16
Average	.96	1.7	3.1	1.5	.94	1.2	2.1	3.6	.48	.36	.24
Maximum	1.9	4.2	8.8	3.9	2.1	2.3	4.5	9.1	.61	.65	.44
Minimum	.30	.63	.71	.51	.37	.49	1.0	1.8	.29	.18	.11
No. Samples	6	7	5	6	4	7	7	7	9	12	12

FWPCA, DPO

TABLE 7 (cont'd)

1967 SAMPLING RESULTS - GRASSY ISLAND AREA

Parameter: Total Soluble Phosphates (as PO_4) (mg/l)

		Wells							DT 14.6		
Date	Pond	3	4	5	6	7	8	9	R37	R41	R43
9-6	-	-	-	-	-	-	-	-	-	-	-
9-13	-	.07	.13	.08	.03	.36	.12	.23	.20	.20	.06
9-20	.46	.02	.11	.04	< .01	.06	.02	1.2	.21	.19	.18
10-3	-	-	-	-	-	-	-	-	.33	.22	.14
10-4	-	2.31	-	.53	.53	.68	1.0	1.4	.27	.30	.23
10-11	.61	.34	.25	.16	.08	.36	.19	.63	.23	.15	.08
10-18	.49	.24	-	.06	-	.22	.24	.90	.30	.18	.18
10-25	-	-	-	-	-	-	-	-	.24	.17	.09
10-26	-	-	-	-	-	-	-	-	.39	.19	.16
11-1	.19	.07	.06	.07	-	.11	.14	.26	-	-	-
11-7	.06	.17	.12	.30	-	.09	.77	.34	.03	.10	.05
11-27	.18	-	-	-	-	-	-	-	-	.15	.07
11-28	-	-	-	-	-	-	-	-	-	.06	.05
11-29	-	-	-	-	-	-	-	-	-	.21	.08
Average	.33	.46	.13	.17	.16	.27	.35	.71	.24	.18	.11
Maximum	.61	2.31	.25	.53	.53	.68	1.0	1.4	.39	.30	.32
Minimum	.06	.02	.06	.04	< .01	.06	.02	.23	.03	.06	.05
No. Samples	6	7	5	7	4	7	7	7	9	12	12

FWPCA, DPO

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Nitrate-N (mg/l)

Date	Pond	Wells							DT 14.6		
		3	4	5	6	7	8	9	R37	R41	R43
9-6	-	-	-	-	-	-	-	-	< .1	< .1	< .1
9-13	-	2.0	1.8	1.6	.7	8.4	4.3	22	.4	.3	.3
9-20	.4	1.5	3.5	.9	.5	1.2	8.2	13	.3	.2	.3
10-3	-	-	-	-	-	-	-	-	.3	.4	.4
10-4	-	.8	-	.5	.2	7.9	.5	2.4	.3	.3	.3
10-11	.4	.8	1.3	.6	.4	9.6	.6	1.2	.3	.3	.3
10-18	1.2	7.5	-	.8	-	19	14	20	.9	.6	.3
10-25	-	-	-	-	-	-	-	-	.4	.4	.4
10-26	-	-	-	-	-	-	-	-	.1	.1	.1
11-1	1.7	1.0	0.2	.4	-	2.6	.2	2.6	-	-	-
11-7	.4	4.0	4.6	.8	-	8.8	5.5	9.2	.4	.2	.3
11-27	.5	-	-	-	-	-	-	-	.3	.3	.3
11-28	-	-	-	-	-	-	-	-	.4	.4	.4
11-29	-	-	-	-	-	-	-	-		.4	.3
Average	.8	2.5	2.3	.8	.5	8.2	4.8	10	.4	.3	.3
Maximum	1.7	7.5	4.6	1.6	.7	19	14	22	.9	.6	.4
Minimum	.4	.8	.2	.4	.2	1.2	.2	1.2	< .1	< .1	< .1
No. Samples	6	7	5	7	4	7	7	7	10	13	13

FWPCA, DPO

TABLE 7 (cont'd)

1967 SAMPLING RESULTS - GRASSY ISLAND AREA

Parameter: Nitrite-N (mg/1)

Date	Pond	Wells							DT 14.6		
		3	4	5	6	7	8	9	R37	R41	R43
9-6	-	-	-	-	-	-	-	-	.01	.01	< .01
9-13	-	.02	-	-	-	.71	1.4	1.0	.01	.01	.01
9-20	< .01	-	-	-	-	.04	.33	.85	.01	.01	.01
10-3	-	-	-	-	-	-	-	-	.01	.01	.01
10-4	-	.01	-	.01	< .01	.26	.02	.29	.01	.01	.01
10-11	.01	.03	.05	.03	.01	.85	.04	.06	.01	.01	.01
10-18	.05	.07	-	.02	-	1.0	.14	.18	.02	.01	.01
10-25	-	-	-	-	-	-	-	-	.02	.01	.01
10-26	-	-	-	-	-	-	-	-	.02	.02	.01
11-1	.06	.03	.02	.02	-	.20	.02	.12	-	-	-
11-7	.08	.04	.03	.03	-	.39	.05	.08	.02	.01	.01
11-27	.04	-	-	-	-	-	-	-	-	.01	.01
11-28	-	-	-	-	-	-	-	-	-	.01	.01
11-29	-	-	-	-	-	-	-	-	-	.01	< .01
Average	.04	.03	.03	.02	< .01	.49	.29	.37	.01	.01	< .01
Maximum	.08	.07	.05	.03	.01	1.0	1.4	1.0	.02	.02	.01
Minimum	< .01	.01	.02	.01	< .01	.04	.02	.06	.01	.01	< .01
No. Samples	6	6	3	5	2	7	7	7	10	13	13

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Ammonia-N (mg/l)

FWPCA, DPO

		Wells							DT 14.6		
Date	Pond	3	4	5	6	7	8	9	R37	R41	R43
9-6	-	1.1	0.9	2.8	2.2	-	2.4	-	0.32	< 0.05	0.18
9-13	-	1.0	0.6	5.9	1.2	1.6	1.7	1.6	0.06	0.06	< 0.05
9-20	18	2.9	1.1	5.7	1.0	1.7	2.9	11.0	0.05	-	-
10-3	-	-	-	-	-	-	-	-	0.18	0.14	< 0.05
10-4	-	3.4	-	3.5	0.6	2.1	5.0	17.0	0.32	0.08	0.18
10-11	21	5.1	0.7	3.5	0.6	2.6	3.2	5.0	0.25	0.12	0.30
10-18	18	3.3	-	3.1	-	2.5	3.3	9.2	0.24	0.14	0.12
10-25	-	-	-	-	-	-	-	-	0.29	0.18	0.18
10-26	-	-	-	-	-	-	-	-	0.36	0.18	0.24
11-1	18	5.6	0.7	3.1	-	1.9	4.2	3.2	-	-	-
11-7	18	4.9	0.8	2.6	-	2.2	4.8	4.2	0.40	-	0.14
11-27	6	-	-	-	-	-	-	-	-	0.18	< 0.05
11-28	-	-	-	-	-	-	-	-	-	0.17	0.10
11-29	-	-	-	-	-	-	-	-	-	0.12	0.08
Average	17	3.4	0.8	3.8	1.1	2.1	3.4	7.3	0.25	0.13	0.14
Maximum	21	5.6	1.1	5.9	2.2	2.6	5.0	17.0	0.40	0.18	0.30
Minimum	6	1.0	0.6	2.6	0.6	1.6	1.7	1.6	0.05	< 0.05	< 0.05
No. Samples	6	8	6	8	5	7	8	7	10	11	12

FWPCA, DPO

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Organic-N (mg/1)

		Wells							DT 14.6		
Date	Pond	3	4	5	6	7	8	9	R37	R41	R43
9-6	-	0.67	0.30	0.32	0.44	-	2.08	-	0.20	0.15	< 0.05
9-13	-	0.37	0.19	< 0.05	< 0.05	0.72	4.70	0.34	< 0.05	0.06	< 0.05
9-20	0.55	0.27	0.22	0.10	< 0.05	0.48	0.66	-	0.08	-	-
10-3	-	-	-	-	-	-	-	-	0.08	0.10	< 0.05
10-4	-	0.90	-	0.14	0.14	0.32	0.37	1.25	0.10	0.10	0.11
10-11	0.06	0.08	0.20	0.18	< 0.05	< 0.05	0.22	0.12	0.31	0.13	0.10
10-18	0.30	0.43	-	0.07	-	0.58	0.30	0.46	0.05	0.07	0.14
10-25	-	-	-	-	-	-	-	-	0.16	< 0.05	< 0.05
10-26	-	-	-	--	-	-	-	-	0.18	0.10	0.08
11-1	0.34	0.34	0.22	0.25	-	0.10	0.27	0.06	-	-	-
11-7	0.22	0.29	0.19	0.13	-	0.29	0.54	0.30	0.08	0.24	0.08
11-27	0.21	-	-	-	-	-	-	-	-	< 0.05	0.06
11-28	-	-	-	-	-	-	-	-	-	0.09	0.18
11-29	-	-	-	-	-	-	-	-	-	0.10	0.11
Average	0.28	0.42	0.22	0.16	0.15	0.36	1.10	0.42	0.13	0.10	0.09
Maximum	0.55	0.90	0.30	0.32	0.44	0.72	4.70	1.25	0.31	0.24	0.18
Minimum	0.06	0.08	0.19	< 0.05	< 0.05	< 0.05	0.22	0.06	< 0.05	< 0.05	< 0.05
No. Samples	6	8	6	8	5	7	8	6	10	12	12

FWPCA, DPO

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Total Coliform (MF/100 ml)

Date	Pond	Wells 3	Wells 4	Wells 5	Wells 6	Wells 7	Wells 8	Wells 9	DT 14.6 R37	DT 14.6 R41	DT 14.6 R43
9-6	-	-	-	-	-	-	-	-	4,600	90,000	23,000
9-13	-	31,000	94,000	35,000	111,000	660,000	200,000	170,000	2,200	2,200	1,300
9-20	16,000	10,000	25,000	10,000	800	30,000	170,000	60,000	34,000	19,000	89,000
10-3	-	-	-	-	-	-	-	-	690	410	400
10-4	-	5,700	-	6,500	390	31,000	25,000	23,000	30,000	7,100	15,000
10-11	25,000	570	3,400	800	140	17,000	1,900	2,300	8,400	4,200	1,600
10-18	15,000	33,000	-	1,800	-	18,000	48,000	330,000	220,000	60,000	4,400
10-25	-	-	-	-	-	-	-	-	2,000	400	900
10-26	-	-	-	-	-	-	-	-	2,200	1,200	750
11-1	8,800	1,000	700	300	-	15,000	1,400	2,800	-	-	-
11-7	1,600	220	60	60	-	1,900	1,900	22,000	120,000	21,000	4,100
11-27	400	-	-	-	-	-	-	-	-	3,700	200
11-28	-	-	-	-	-	-	-	-	-	600	70
11-29	-	-	-	-	-	-	-	-	-	2,800	100
Average	12,000	5,700	3,400	1,800	600	18,000	25,000	23,000	6,500	3,700	1,300
Maximum	25,000	33,000	94,000	35,000	111,000	660,000	200,000	330,000	220,000	90,000	89,000
Minimum	400	220	60	60	140	1,900	1,400	2,300	690	400	70
No. Samples	6	7	5	7	4	7	7	7	10	13	13

FWPCA, DPO

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Fecal Coliform (MF/100 ml)

		Wells							DT 14.6		
Date	Pond	3	4	5	6	7	8	9	R37	R41	R43
9-6	-	-	-	-	-	-	-	-	220	8,300	120
9-13	-	160	20	< 10	40	1,900	420	2,000	130	90	130
9-20	830	160	90	480	30	50	4,000	11,000	1,300	480	2,600
10-3	-	-	-	-	-	-	-	-			
10-4	-	-	-	-	-	-	-	-	-	-	-
10-11	750	160	10	50	< 10	260	110	60	810	340	30
10-18	300	700	-	10	-	110	290	1,000	23,000	4,300	210
10-25	-	-	-	-	-	-	-	-	100	< 100	< 100
10-26	-	-	-	-	-	-	-	-	130	20	30
11-1	630	10	< 10	< 10	-	10	10	20	-	-	-
11-7	44	18	< 2	< 2	-	220	50	12	9,400	890	360
11-27	10	-	-	-	-	-	-	-	-	310	10
11-28	-	-	-	-	-	-	-	-	-	48	6
11-29	-	-	-	-	-	-	-	-	-	250	10
Average	470	160	10	< 10	30	170	200	530	520	310	< 100
Maximum	830	700	90	480	40	1,900	4,000	11,000	23,000	8,300	2,600
Minimum	10	10	< 2	< 2	< 10	10	10	12	100	20	6
No. Samples	6	6	5	6	3	6	6	6	8	11	11

FWPCA, DPO

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Total Solids (mg/l)

		Wells							DT 14.6		
Date	Pond	3	4	5	6	7	8	9	R37	R41	R43
9-6	-	-	-	-	-	-	-	-	190	190	170
9-13	-	3900	4000	1600	2500	4300	3300	1200	190	190	170
9-20	720	2700	9100	1400	2200	3900	1800	1000	180	180	170
10-3	-	-	-	-	-	-	-	-	160	140	150
10-4	-	3600	-	1800	2300	4100	1600	2300	220	170	150
10-11	670	2900	3300	1700	2300	3800	4800	1200	180	180	160
10-18	600	3300	-	1400	-	3400	1600	1800	220	150	140
10-25	-	-	-	-	-	-	-	-	190	170	160
10-26	-	-	-	-	-	-	-	-	220	180	160
11-1	670	2700	5200	1400	-	4000	1800	1500	-	-	-
11-7	600	3400	5500	1700	-	3400	1800	1400	290	160	180
11-27	680	-	-	-	-	-	-	-	-	160	150
11-28	-	-	-	-	-	-	-	-	-	160	150
11-29	-	-	-	-	-	-	-	-	-	140	150
Average	660	3200	5400	1600	2300	3800	2400	1500	200	170	160
Maximum	720	3900	9100	1800	2500	4300	4800	2300	290	190	180
Minimum	600	2700	3300	1400	2200	3400	1600	1000	160	140	140
No. Samples	6	7	5	7	4	7	7	7	10	13	13

FWPCA, DPO

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Suspended Solids (mg/1)

		Wells							DT 14.6		
Date	Pond	3	4	5	6	7	8	9	R37	R41	R43
9-6		-	-	-	-	-	-	-	11	25	5
9-13	-	790	290	710	340	200	980	400	29	14	10
9-20	89	620	5700	400	180	140	380	220	30	26	22
10-3	-	-	-	-	-	-	-	-	23	19	15
10-4	-	1200	-	160	120	190	310	1600	23	26	18
10-11	62	200	420	480	100	90	3100	330	23	40	18
10-18	39	1000	-	250	-	100	290	1100	39	20	11
10-25	-	-	-	-	-	-	-	-	33	26	30
10-26	-	-	-	-	-	-	-	-	43	49	44
11-1	62	250	2300	140	-	570	460	490	-	-	-
11-7	35	780	2200	170	-	68	330	49	88	23	33
11-2	34	-	-	-	-	-	-	-	-	-	-
11-2	20	-	-	-	-	-	-	-	-	-	-
11-2	33	-	-	-	-	-	-	-	-	28	24
11-28	-	-	-	-	-	-	-	-	-	36	30
11-29	-	-	-	-	-	-	-	-	-	21	-
Average	47	680	2200	330	190	190	840	600	34	27	22
Maximum	89	1100	5700	710	340	570	3100	1600	88	49	44
Minimum	20	200	290	140	100	68	290	49	11	14	5
No. Samples	8	7	5	7	4	7	7	7	10	13	12

FWPCA, DPO

TABLE 7 **(cont'd)**
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Dissolved Solids (mg/l)

Date	Pond	Wells							DT 14.6		
		3	4	5	6	7	8	9	R37	R41	R43
9-6	-	-	-	-	-	-	-	-	180	160	160
9-13	-	3100	3700	930	2100	4100	2400	790	160	170	160
9-20	630	2100	3400	960	2100	3800	1400	740	150	150	150
10-3	-	-	-	-	-	-	-	-	130	120	140
10-4	-	2500	-	1700	2200	3900	1200	740	200	150	130
10-11	610	2700	2900	1200	2200	3800	1800	900	160	140	140
10-18	560	2300	-	1200	-	3300	1300	730	180	130	120
10-25	-	-	-	-	-	-	-	-	160	150	130
10-26	-	-	-	-	-	-	-	-	180	130	120
11-1	600	2400	2900	1300	-	3500	1300	1000	-	-	-
11-7	560	2600	3300	1500	-	3400	1400	910	200	130	150
11-27	640	-	-	-	-	-	-	-	-	130	120
11-28	-	-	-	-	-	-	-	-	-	130	120
11-29	-	-	-	-	-	-	-	-	-	120	-
Average	600	2500	3200	1300	2200	3700	1500	830	170	140	140
Maximum	640	3100	3700	1700	2200	4100	2400	1000	200	170	160
Minimum	560	2100	2900	930	2100	3300	1200	730	130	120	120
No. Samples	6	7	5	7	4	7	7	7	10	13	12

FWPCA, DPO

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Total Volatile Solids (mg/1)

Date	Pond	Wells							DT 14.6		
		3	4	5	6	7	8	9	R37	R41	R43
9-6	-	-	-	-	-	-	-	-	89	53	5
9-13	-	540	930	280	540	1100	580	360	89	69	73
9-20	180	490	890	350	450	750	360	240	64	80	40
10-3	-	-	-	-	-	-	-	-	36	24	34
10-4	-	780	-	530	600	950	350	450	85	55	13
10-11	160	720	810	470	590	950	890	280	67	60	57
10-18	130	520	-	320	-	680	340	400	56	85	31
10-25	-	-	-	-	-	-	-	-	59	55	40
10-26	-	-	-	-	-	-	-	-	66	43	42
11-1	190	580	880	400	-	780	370	320	-	-	-
11-7	180	670	990	410	-	760	440	420	74	38	40
11-27	170	-	-	-	-	-	-	-	-	56	51
11-28	-	-	-	-	-	-	-	-	-	36	49
11-29	-	-	-	-	-	-	-	-	-	49	50
Average	170	610	900	390	550	850	480	350	69	54	40
Maximum	190	780	990	530	600	1100	890	450	89	85	73
Minimum	130	490	810	280	450	680	340	240	36	24	5
No. Samples	6	7	5	7	4	7	7	7	10	13	13

FWPCA, DPO

TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Volatile Suspended Solids (mg/1)

Date	Pond	Wells							DT 14.6		
		3	4	5	6	7	8	9	R37	R41	R43
9-6	-	-	-	-	-	-	-	-	1	2	1
9-13	-	56	22	42	38	32	120	62	8	1	2
9-20	24	58	340	40	21	48	56	47	10	8	5
10-3	-	-	-	-	-	-	-	-	6	4	4
10-4	-	120	-	23	14	41	54	250	7	9	3
10-11	24	28	42	37	15	33	390	61	7	9	5
10-18	12	92	-	21	-	29	41	150	1	5	3
10-25	-	-	-	-	-	-	-	-	2	2	9
10-26	-	-	-	-	-	-	-	-	7	5	6
11-1	6	34	180	18	-	44	56	92	-	-	-
11-7	16	62	140	17	-	15	44	68	14	2	3
11-27	10	-	-	-	-	-	-	-	-	9	7
11-28	-	-	-	-	-	-	-	-	-	6	10
11-29	-	-	-	-	-	-	-	-	-	1	-
Average	15	64	140	28	22	35	110	100	6	5	5
Maximum	24	120	340	42	38	48	390	250	14	9	10
Minimum	6	28	22	17	14	15	41	47	1	1	1
No. Samples	6	7	5	7	4	7	7	7	10	13	12

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TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Iron (mg/l)

Date	Pond	Wells 3	4	5	6	7	8	9	DT 14.6 R37	R41	R43
9-6	-	-	-	-	-	-	-	-	.56	.98	.27
9-13	-	94	15	37	5.6	9.1	34	9.8	.89	.71	.55
9-20	8.3	28	230	19	7.4	12	8.0	10	.61	.39	.27
10-3	-	-	-	-	-	-	-	-	.47	.32	.23
10-4	-	54	-	9.6	3.0	12	9.8	76	.78	.61	.37
10-11	2.4	9.5	10	17	5.6	13	57	15	.95	1.5	.56
10-18	2.4	48	-	14	-	8.5	8.6	40	1.7	.50	.13
10-25	-	-	-	-	-	-	-	-	.85	.65	.68
10-26	-	-	-	-	-	-	-	-	1.4	1.1	1.2
11-1	4.1	21	13	9.5	-	16	6.0	11	-	-	-
11-7	1.8	30	77	8.3	-	9.[illegible]	7.6	21	3.2	.81	.97
Average	3.8	41	69	16	5.4	11	19	26	1.1	.76	.52
Maximum	8.3	94	230	37	7.4	16	57	76	3.2	1.5	1.2
Minimum	1.8	9.5	10	8.3	3.0	8.5	6.0	9.8	.47	.32	.13
No. Samples	5	7	5	7	4	7	7	7	10	10	10

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TABLE 7 (cont'd)

1967 SAMPLING RESULTS - GRASSY ISLAND AREA

Parameter: Oil and Grease (mg/1)

		Wells							DT 14.6		
Date	Pond	3	4	5	6	7	8	9	R37	R41	R43
9-6	-	-	-	-	-	-	-	-	-	-	-
9-13		9	7	5	7	8	14	14	4	11	15
9-20	10	10	12	5	7	10	11	6	10	10	11
10-3	-	-	-	-	-	-	-	-	3	3	5
10-4	-	7	-	2	3	4	4	4	1	2	1
10-11	3	3	3	4	3	6	8	4	4	3	3
10-18	2	2	-	3	-	3	3	3	2	2	1
10-25	-	-	-	-	-	-	-	-	2	2	2
10-26	-	-	-	-	-	.	-	-	2	2	3
11-27	4									4	4
11-28										4	3
11-29										5	3
Average	5	6	7	4	5	6	8	6	4	4	5
Maximum	10	10	12	5	7	10	14	14	10	11	15
Minimum	2	2	3	2	3	3	3	3	1	2	1
No. Samples	4	4	3	5	4	5	5	5	8	11	11

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TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Turbidity (Jackson Units)

		Wells							DT 14.6		
Date	Pond	3	4	5	6	7	8	9	R37	R41	R43
9-6	-	-	-	-	-	-	-	-	< 25	< 25	< 25
9-13	-	2300	550	1200	340	140	1200	480	25	< 25	< 25
9-20	150	650	650	210	140	170	310	170	< 25	< 25	< 25
10-3	-	-	-	-	-	-	-	-	< 25	< 25	< 25
10-4	-	1000	-	130	75	220	280	900	< 25	< 25	< 25
10-11	25	120	340	360	120	120	2600	270	< 25	< 25	< 25
10-18	100	1000	-	320	-	100	270	390	< 25	< 25	< 25
10-25	-	-	-	-	-	-	-	-	25	< 25	< 25
10-26	-	-	-	-	-	-	-	-	40	40	35
11-1	130	230	2400	140	-	520	320	550	-	-	-
11-7	30	650	2100	45	-	110	180	560	< 25	-	< 25
Average	87	850	1200	340	170	200	740	470	27	27	26
Maximum	150	2300	2400	1200	340	520	2600	900	40	40	35
Minimum	25	230	340	45	75	100	180	170	< 25	< 25	< 25
No. Samples	5	7	5	7	4	7	7	7	10	9	10

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TABLE 7 (cont'd)
1967 SAMPLING RESULTS - GRASSY ISLAND AREA
Parameter: Sulfate (mg/l)

Date	Pond	Wells							DT 14.6		
		3	4	5	6	7	8	9	R37	R41	R43
9-6	-	650	1500	240	720	-	360	-	15	-	14
9-13	-	320	1300	38	880	1400	760	250	20	17	13
9-20	50	950	1700	150	820	1600	570	90	17	16	15
10-3	-	-	-	-	-	-	-	-	28	-	15
10-4	-	1000	-	540	950	1600	410	80	18	16	16
10-11	34	1100	1500	270	930	1500	380	120	16	14	14
10-18	34	1100	-	290	-	1400	440	120	20	17	16
10-25	-	-	-	-	-	-	-	-	15	13	13
10-26	-	-	-	-	-	-	-	-	17	14	13
11-1	44	1100	1400	290	-	1300	270	120	-	-	-
11-7	40	1100	1400	380	-	1300	470	130	16	15	38
Average	40	920	1500	280	860	1400	460	130	18	15	17
Maximum	50	1100	1700	540	950	1600	760	250	28	17	38
Minimum	34	320	1300	38	720	1300	270	80	15	13	13
No. Samples	5	8	6	8	5	7	8	7	10	8	10

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Table 8
City of Wyandotte
Filter Plant Records
Raw Water Analyses
1967

DATE	TURBIDITY UNITS	CHLORIDES mg/1	ALKALINITY mg/1	COLIFORM MPN/100 ml
8-21	6	-	-	4,300
8-22	6	12	80	15,000
8-23	7	-	-	4,300
8-24	8	11.5	80	4,300
8-25	8	-	-	4,300
8-26*	7	14	78	3,900
8-27	6	-	-	2,300
8-28	7	12	80	7,500
8-29	7	-	-	2,300
8-30*	7	12	80	4,300
8-31	9	-	-	210
9-1	10	11.5	80	2,400
2	7	-	-	930
-3	6	11	80	4,600
9-4	6	-	-	4,600
9-5	6	12.5	80	930
9-6	7	-	-	2,400
9-7	6	13	80	4,600
9-8	6	-	-	2,400
9-9	6	12.5	80	2,400
9-10	6	-	-	2,400
9-11	12	11.5	81	750
9-12	14	-	-	11,000
9-13	11	11.5	78	750
9-14	10	-	-	3,900
9-15	7	12	80	9,300
9-16	7	-	-	24,000
9-17	7	11.5	78	110,000
9-18	7	-	-	4,300
9-19	6	12	80	4,300
9-20	6	-	-	4,300
9-21*	7	12	82	2,300
9-22	7	-	-	46,000
9-23	7	12.5	80	24,000
9-24	7	-	-	24,000
9-25	7	11.5	82	1,200
9-26	8	-	-	2,400
9-27*	8	10	80	24,000
-28	13	-	-	9,300
9-29*	32	11	82	4,300
9-30	39		-	4,300

*Probable Stormwater Overflow
/Grassy Island Overflow Pipe Open

Table 8 (cont.)
City of Wyandotte
Filter Plant Records
Raw Water Analyses
1967

FWPCA, DPO

DATE	TURBIDITY UNITS	CHLORIDES mg/l	ALKALINITY mg/l	COLIFORM MPN/100 ml
10-1	18	10	78	4,300
10-2	13	-	-	2,300
10-3	12	10	82	2,300
10-4	10	-	-	4,300
10-5	15	10	82	9,300
10-6#	14	-	-	750
10-7#	18	11	80	4,300
10-8*#	24	-	-	9,300
10-9#	22	19	80	46,000
10-10	20	-	-	15,000
10-11	14	20	80	4,300
10-12	12	-	-	2,300
10-13	13	20	80	4,300
10-14	11	-	-	2,300
10-15*	12	11.5	80	9,300
10-16*	19	-	-	110,000
10-17*	17	14	80	9,300
10-18	12	-	-	46,000
10-19	11	12	80	15,000
10-20	11	-	-	24,000
10-21	12	12	80	2,300
10-22	11	-	-	930
10-23	11	8.5	80	9,300
10-24	11	-	-	24,000
10-25#	15	11.5	82	2,300
10-26#	16	-	-	2,300
10-27*#	28	9.5	80	4,300
10-28	36	-	-	2,300
10-29	17	10	80	4,300
10-30	18	-	-	4,300
10-31	35	8	80	3,900
11-1*	31	-	-	2,300
11-2	28	9	76	110,000
11-3*	19	-	-	4,300
11-4	11	11	80	9,300
11-5	10	-	-	[illegible],300
11-6	12	12.5	80	110,000
11-7	12	-	-	4,300
11-8	14	12	80	4,300
11-9	13	-	-	4,300
11-10	13	12	78	3,900

*Probable Stormwater Overflow
#Grassy Island Overflow Pipe Open

Table 8 (cont.)
City of Wyandotte
Filter Plant Records
Raw Water Analyses
1967

FWPCA, DPO

DATE	TURBIDITY UNITS	CHLORIDES mg/1	ALKALINITY mg/1	COLIFORM MPN/100 ml
11-11*	11	-	-	9,300
11-12	14	12.5	80	4,300
11-13	16	-	-	1,500
11-14	14	14	78	930
11-15	17	-	-	4,600
11-16	19	10.5	82	430
11-17*	28	-	-	9,300
11-18	17	12.5	78	4,300
11-19	15	-	-	4,300
11-20	14	6	80	4,300
11-21	14	-	-	4,300
11-22	11	6	80	9,300
11-23	12	-	-	4,300
11-24	12	10.5	80	930
11-25	9	-	-	1,500
11-26	9	7.5	80	4,600
11-27#	10	-	-	930
11-28#	12	8	80	750
11-29#	8	-	-	2,400
11-30#	11	8.5	80	2,400
12-1#	28	10	94	15,000
12-2*#	21	-	-	3,900
12-3#	21			21,000

*Probable Stormwater Overflow
#Grassy Island Overflow Pipe Open

Overflow and Leakage

On October 2, 3, and 4, the field crew reported overflow of the Grassy Island dike at points on the north and east side of Grassy Island. Samples of the overflow were collected on October 3.

On three occasions, an overflow pipe (approximately 21 inches in diameter) located on the west side of the island (see Figure 7) was opened to drain the accumulated supernatent liquid. During the discharges which commenced on October 25 and November 27, samples were collected with a dip sampler directly from the overflow. Some leakage did occur even when the overflow pipe was sealed with a metal plate. Results of the analyses of dike overflow, leakage through overflow pipe, and the discharge through the overflow pipe are shown in Table 9 .

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Table 9
Rouge River Pilot Study
Grassy Island Overflow & Leakage

Date	Time	Type of Discharge	Estimated Flow (CFS)	Pond Water Level
10-3	1030	Overflow of dike 500' N. of well 7	< .1	576.8
10-3	1100	Overflow of dike 40' E. of well 6	< .1	576.8
10-6		Overflow pipe opened at 1530 (no sample taken)		576.8
10-25	1438	Overflow pipe opened at 1433	20	576.8
10-25	1503	Overflow pipe open	10	576.8
10-26	1015	Overflow pipe open	10	575.6
11-1	1045	Leakage; overflow pipe	< .1	575.0
11-7	1155	Leakage; overflow pipe	< .1	576.0
11-15	1145	Leakage; overflow pipe	< .1	576.7
11-27	1047	Overflow pipe opened at 1017	20	576.6
11-28	0920	Overflow pipe open	10	-
11-29	1040	Overflow pipe open	3	574.7

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Rouge River Pilot Study 1967
Grassy Island Leakage & Overflow

Table 9 (cont.)

	Date	Time	Temp °C	DO mg/1	Phenols ug/1	pH S.U.	Cond. umho/cm	Chloride mg/1	Total Phos PO_4 mg/1	Total Ortho PO_4 mg/1	Nitrate NO_3 mg/1	Nitrite NO_2 mg/1	BOD mg/1	COD mg/1	Ammonia NH_3 mg/1	Organic Nitrogen mg/1	Oil mg/1	Iron mg/1
	10-3	1030	16.0	-	490	-	-	200	2100	2000	22	.06	3500	40,000	98	65	7200	180
	10-3	1100	15.0	-	6	7.7	1000	130	1.0	1.0	.4	.03	16	120	17	.42	3	1.5
(1)	10-25	1438	10.5	5.7	17	7.4	950	120	1.0	.47	.6	.11	11	94	19	.06	4	2.7
(1)	10-25	1503	10.0	5.4	12	7.8	930	120	.80	.36	.5	.11	10	91	15	.10	3	2.5
(1)	10-2?	1015	8.0	3.0	10	8.1	930	120	.89	.39	.2	.13	11	94	18	.29	3	2.1
(2)	11-1	1045	10.0	4.0	15	7.7	1000	150	.88	.21	.2	.06	11	91	17	.37	-	2.0
(2)	11-7	1155	3.5	5.4	-	8.2	950	120	.46	.03	.4	.10	9*	81	-	-	-	.66
(2)	11-15	1145	0.0	9.5	9	8.0	1000	130	.52	.18	.5	.08	15	84	16	.16	-	3.2
(1)	11-27	1147	1.0	8.2	5	8.2	1000	170	.54	.20	.4	.04	9	86	13	.24	-	-
(1)	11-28	0920	0.0	9.8	5	8.2	1000	160	.40	.22	.5	.03	11*	60	14	.19	3	-
(1)	11-29	1040	0.0	8.9	6	8.1	1000	170	.34	.22	.8	.03	7	60	15	.26	3	-
(1)	Overflow Pipe																	
		Ave.	5.0	6.8	9	8.0	970	140	.66	.31	.5	.08	10	81	16	.17	3	2.4
		Max.	10.5	9.8	17	8.2	1000	170	1.0	.47	.8	.13	11	94	19	.29	4	2.7
		Min.	0.0	3.0	5	7.4	930	120	.34	.20	.2	.03	7	60	13	.06	3	2.1
		N.S.	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	3
(2)	Overflow Pipe Leakage																	
		Ave.	4.5	6.3	12	8.0	980	130	.62	.14	.4	.08	12	85	16	.26	-	2.0
		Max.	10.0	9.5	15	8.2	1000	150	.88	.21	.5	.10	15	91	17	.37	-	3.2
		Min.	0.0	4.0	9	7.7	[illegible]	120	.46	.03	.2	.06	9	81	16	.16	-	.86
		N.S.	3	3	2	3	3	3	3	3	3	3	3	3	2	2	-	3

*Estimated
**Median

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Rouge River Pilot Study 1967

Grassy Island Leakage & Overflow

Table 9 (cont.)

		Time	Temp °C	Turb J.C.U.	Alkalinity mg/1	Total Solids mg/1	Diss Solids mg/1	Total Vol.Sol. mg/1	Susp. Solids mg/1	Vol.Sus Solids mg/1	Sulfate mg/1	Total Coli. MF/100ml	Fecal Coli. MF/100
	10-3	1030	16.0	-	-	230,000	5300	26000	230,000	26000	-	870,000	-
	10-3	1100	15.0	26	290	660	620	170	37	19	15	4,000	-
(1)	10-25	1438	10.5	53	170	590	540	160	50	22	34	1,800	70
(1)	10-25	1503	10.0	52	260	570	540	140	38	19	32	1,700	70
(1)	10-26	1015	8.0	57	270	580	540	150	41	14	36	3,100	10
(2)	11-1	1045	10.0	77	280	650	610	190	34	4	38	5,100	510
(2)	11-7	1155	3.5	< 25	260	590	560	180	32	9	21	850	32
(2)	11-15	1145	0.0	82	260	670	630	210	38	8	45	7,900	730
(1)	11-27	1147	1.0	-	250	700	660	230	34	12	-	700	10
(1)	11-28	0920	0.0	-	250	710	630	220	78	16	-	2,000	24
(1)	11-29	1040	0.0	-	280	710	640	230	68	28	-	570	10
(1)	Overflow Pipe												
		Ave.	5.0	54	250	640	590	190	52	19	34	1,800**	17**
		Max.	10.5	57	280	710	660	230	78	28	36	3,100	70
		Min.	0.0	52	170	570	540	140	34	12	32	570	10
		N.S.	6	3	6	6	6	6	6	6	3	6	6
(2)	Overflow Pipe Leakage												
		Ave.	4.5	61	270	640	600	190	35	7	35	5,100**	510**
		Max.	10.0	82	280	670	630	210	38	9	45	7,900	730
		Min.	0.0	< 25	260	590	560	180	32	4	21	850	32
		N.S.	3	3	3	3	3	3	3	3	3	3	3

*Estimated
**Median

Observations

The extent of the filled area inside the dike, as determined by a survey conducted on September 6, is shown in Figure 7. By September 11, the sludge had extended to the dikes on all sides and the depth of the material accumulated inside the dike began to show a noticeable increase. A Belfort recorder was installed within the diked area to record these changes in water level as the dredging progressed. Similar recorders were installed in the Detroit River, at well #3, and at well #5. The Belfort records along with weekly observations and measurements performed by the field crew are presented in Figure 8. On October 2, 3, and 4 the field crew reported overflow of the dike on the north and east sides of the island. Samples of the overflows were collected on October 3 near wells 6 and 7. On October 6, the overflow pipe was opened and an estimated 13 million gallons of supernatent drained into the Detroit River during a 48-hour period. The overflow pipe was also opened on two other occasions as previously discussed (October 25 and November 27). Even when the overflow pipe was sealed with a metal plate, leakage (estimated at less than .1 cfs) was observed.

C. Past Records

Data collected by various agencies at DT 14.6W between 1963 and 1967 were divided into two groups: dredging and non-dredging periods. The average temperature, phenol and chloride concentrations and median coliform densities measured at five stations on DT 14.6W are shown for dredging and non-dredging periods since 1963. (See Table 10)

Analytical statistical results* during the 1963 non-dredging period for stations R139 and R142 (on Detroit River range DT 19.0) and T15 (on the Rouge River) are given in Table 11 . Phenol and chloride concentrations for 1963 appear higher than 1967 Pilot Study results while coliform densities are lower.

*Detroit River Lake Erie Project, U.S. Public Health Service

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Table 10
Statistics of Water Quality
Dredging & Non-Dredging Periods
Detroit River

Range: DT14.6W
Station: R36 (400' from U.S. Shore)

		Temp °C	Phenols ug/1	Cl. mg/1	Total Coliform* MF/100 ml
1963 Dredging Period	Ave.	12.2	6	19	3100
	Max.	20.5	8	20	3200
	Min.	3.0	4	19	600
	N.S.	3	3	3	3
1963 Non-Dredging Period	Ave.	13.6	8	21	2750
	Max.	26.0	23	32	520,000
	Min.	6.0	1	15	560
	N.S.	14	6	8	14
1964 Dredging Period	Ave.	15.0	9	-	31,100
	Max.	18.0	14	-	60,000
	Min.	12.0	3	-	2200
	N.S.	2	2	-	2
1964 Non-Dredging Period	Ave.	22.8	4	-	97,500
	Max.	25.5	7	-	290,000
	Min.	19.5	0	-	1000
	N.S.	6	6	-	6
1965 Dredging Period	Ave.	-	7	15	4,000
	Max.	-	7	16	6,700
	Min.	-	6	14	1,300
	N.S.	-	2	2	2
1965 Non-Dredging Period	Ave.	13.1	3	14	4,750
	Max.	18.0	6	14	120,000
	Min.	7.0	0	14	300
	N.S.	4	7	1	8
1966 Dredging Period	Ave.	12.2	4	20	1,600
	Max.	15.0	11	23	2,500
	Min.	8.0	0	15	900
	N.S.	3	3	3	3
1966 Non-Dredging Period	Ave.	18.1	6	22	3,300
	Max.	24.0	11	44	5,500
	Min.	9.0	0	14	< 300
	N.S.	7	6	7	7
1967 Dredging Period	Ave.	12.2	7	19	15,000
	Max.	15.0	10	23	22,000
	Min.	9.5	4	14	7,400
	N.S.	2	2	2	2
1967 Non-Dredging Period	Ave.	15.0	8	16	13,000
	Max.	22.0	18	19	120,000
	Min.	9.0	< 1	12	3,300
	N.S.	5	6	6	6

*Median (not average) shown for bacteriological data

FWPCA, DPO

Table 10 (cont.)
Statistics of Water Quality
Dredging & Non-Dredging Periods
Detroit River

Range: DT14.6W
Station: R38 (800' from U.S. Shore)

		Temp °C	Phenols ug/1	Cl. mg/1	Total Coliform* MF/100 ml
1963 Dredging Period	Ave.	12.2	3	12	2800
	Max.	20.5	6	13	4500
	Min.	3.0	1	11	500
	N.S.	3	3	3	3
1963 Non-Dredging Period	Ave.	13.3	6	15	2000
	Max.	26.0	16	17	440,000
	Min.	5.5	0	10	200
	N.S.	13	6	9	13
1964 Dredging Period	Ave.	15.3	4	-	12,950
	Max.	18.0	8	-	25,000
	Min.	12.5	0	-	900
	N.S.	2	2	-	2
1964 Non-Dredging Period	Ave.	22.6	4	-	47,500
	Max.	25.5	9	-	290,000
	Min.	19.0	0	-	3,000
	N.S.	6	6	-	6
1965 Dredging Period	Ave.	-	5	13	24,500
	Max.	-	5	13	48,000
	Min.	-	5	12	1,000
	N.S.	-	2	2	2
1965 Non-Dredging Period	Ave.	12.8	3	13	3,950
	Max.	18.0	4	13	59,000
	Min.	6.0	0	13	1,200
	N.S.	4	7	1	8
1966 Dredging Period	Ave.	12.2	2	14	1,400
	Max.	15.0	5	15	1,400
	Min.	8.0	0	13	400
	N.S.	3	3	3	3
1966 Non-Dredging Period	Ave.	18.0	6	15	1,000
	Max.	24.0	9	23	9,300
	Min.	9.0	0	12	< 300
	N.S.	7	7	7	7
1967 Dredging Period	Ave.	12.5	6	15	13,000
	Max.	15.5	10	18	18,000
	Min.	9.5	2	12	7,100
	N.S.	2	2	2	2
1967 Non-Dredging Period	Ave.	15.0	9	14	4,600
	Max.	22.0	19	15	140,000
	Min.	9.0	1	12	2,000
	N.S.	5	5	6	6

*median (not average) values shown for bacteriological data

FWPCA, DPO

Table 10 (cont.)
Statistics of Water Quality
Dredging & Non-Dredging Periods
Detroit River

Range: DT14.6W
Station: R40 (1000' from U.S. Shore)

		Temp °C	Phenols ug/l	Cl. mg/l	Total Coliform* MF/100 ml
1963	Ave.	12.3	4	12	1800
Dredging	Max.	21.0	8	18	2200
Period	Min.	3.0	1	9	1100
	N.S.	3	3	3	3
1963	Ave.	13.2	4	19	1100
Non-	Max.	26.0	11	54	380,000
Dredging	Min.	5.5	1	12	160
Period	N.S.	13	5	9	13
1964	Ave.	15.0	5	-	9,850
Dredging	Max.	17.5	5	-	19,000
Period	Min.	12.5	4	-	700
	N.S.	2	2	-	2
1964	Ave.	22.5	3	-	43,500
Non-	Max.	25.5	5	-	260,000
Dredging	Min.	19.0	0	-	1000
Period	N.S.	6	6	-	6
1965	Ave.	-	4	11	19,250
Dredging	Max.	-	4	12	38,000
Period	Min.	-	3	9	500
	N.S.	-	2	2	2
1965	Ave.	12.5	3	13	3,050
Non-	Max.	17.5	13	13	58,000
Dredging	Min.	6.0	0	13	600
Period	N.S.	4	8	1	8
1966	Ave.	12.0	2	13	400
Dredging	Max.	15.0	4	14	1,200
Period	Min.	7.5	0	12	200
	N.S.	3	3	3	3
1966	Ave.	17.9	5	14	1,400
Non-	Max.	24.0	9	20	4,300
Dredging	Min.	8.5	0	12	360
Period	N.S.	7	7	7	7
1967	Ave.	12.5	6	13	7,400
Dredging	Max.	15.5	9	14	8,200
Period	Min.	9.5	3	12	6,700
	N.S.	2	2	2	2
1967	Ave.	15.0	7	13	3,700
Non-	Max.	22.0	14	15	< 150,000
Dredging	Min.	9.0	< 1	8	250
Period	N.S.	5	6	6	6

*Median (not average) values shown for bacteriological data

Table 10 (cont.)
Statistics of Water Quality
Dredging & Non-Dredging Periods
Detroit River

FWPCA, DPO

Range: DT14.6W
Station: R42 (2000' from U.S. Shore)

		Temp °C	Phenols ug/l	Cl. mg/l	Total Coliform* MF/100 ml
1963 Dredging Period	Ave.	12.0	2	9	1400
	Max.	20.5	3	10	1900
	Min.	3.0	1	8	1400
	N.S.	3	3	3	3
1963 Non-Dredging Period	Ave.	12.8	2	19	1200
	Max.	25.5	4	47	200,000
	Min.	5.0	0	10	80
	N.S.	13	5	8	13
1964 Dredging Period	Ave.	14.8	5	-	3,950
	Max.	17.5	5	-	7,600
	Min.	12.0	4	-	300
	N.S.	2	2	-	2
1964 Non-Dredging Period	Ave.	22.4	3	-	58,000
	Max.	25.5	7	-	620,000
	Min.	19.0	0	-	2,000
	N.S.	6	6	-	6
1965 Dredging Period	Ave.	-	3	9	21,750
	Max.	-	3	10	43,000
	Min.	-	3	8	500
	N.S.	-	2	2	2
1965 Non-Dredging Period	Ave.	12.4	3	12	2,250
	Max.	17.5	7	12	27,000
	Min.	5.5	0	12	310
	N.S.	4	8	1	8
1966 Dredging Period	Ave.	11.8	4	10	500
	Max.	14.5	9	11	1,100
	Min.	7.5	0	9	500
	N.S.	3	3	3	3
1966 Non-Dredging Period	Ave.	17.5	3	12	900
	Max.	23.5	9	17	9,300
	Min.	8.0	0	10	< 300
	N.S.	7	7	7	7
1967 Dredging Period	Ave.	12.0	2	10	3,200
	Max.	15.0	2	11	3,900
	Min.	9.0	2	10	2,400
	N.S.	2	2	2	2
1967 Non-Dredging Period	Ave.	14.7	7	11	1,600
	Max.	22.0	13	14	> 150,000
	Min.	8.5	3	6	< 10
	N.S.	5	6	6	6

*Median (not average) values shown for bacteriological data

Table 10 (cont.)
Statistics of Water Quality
Dredging & Non-Dredging Periods
Detroit River

FWPCA, DPO

Range: DT14.6W
Station: R44 (3000' from U.S. Shore)

		Temp °C	Phenols ug/l	Cl. mg/l	Total Coliform* MF/100 ml
1963 Dredging Period	Ave.	11.8	2	9	600
	Max.	20.0	4	10	1300
	Min.	3.0	0	8	420
	N.S.	3	3	3	3
1963 Non-Dredging Period	Ave.	12.5	2	13	420
	Max.	25.5	6	33	50,000
	Min.	4.5	0	7	10
	N.S.	13	5	9	13
1964 Dredging Period	Ave.	14.5	5	-	1,100
	Max.	17.5	7	-	1,800
	Min.	11.5	3	-	400
	N.S.	2	2	-	2
1964 Non-Dredging Period	Ave.	22.3	2	-	31,500
	Max.	25.5	5	-	220,000
	Min.	19.0	0	-	1,200
	N.S.	6	5	-	6
1965 Dredging Period	Ave.	-	3	9	1,850
	Max.	-	3	9	3,400
	Min.	-	2	9	300
	N.S.	-	2	2	2
1965 Non-Dredging Period	Ave.	12.0	3	11	1,550
	Max.	17.5	8	11	16,000
	Min.	5.0	0	11	90
	N.S.	4	8	1	8
1966 Dredging Period	Ave.	11.7	0	9	200
	Max.	14.5	1	10	300
	Min.	7.5	0	9	200
	N.S.	3	3	3	3
1966 Non-Dredging Period	Ave.	17.4	2	12	500
	Max.	23.5	9	18	4,300
	Min.	8.0	0	9	< 300
	N.S.	7	7	7	7
1967 Dredging Period	Ave.	12.0	3	12	320
	Max.	15.0	5	12	350
	Min.	9.0	1	11	290
	N.S.	2	2	2	2
1967 Non-Dredging Period	Ave.	14.3	4	10	960
	Max.	22.0	12	12	93,000
	Min.	8.5	< 1	5	200
	N.S.	5	6	6	6

*Median (not average) values shown for bacteriological data

FWPCA, DPO

Table 11
Water Quality Statistics
1963 Non-Dredging Period

R139

	Temp (°C)	Phenols (ug/1)	Chlorides (mg/1)	Total Coliform* (MF/100 ml)
Ave.	17.0	28	35	6,000
Max.	27.0	79	42	440,000
Min.	7.0	8	28	1,300
N.S.	7	5	5	7

R142

	Temp (°C)	Phenols (ug/1)	Chlorides (mg/1)	Total Coliform* (MF/100 ml)
Ave.	16.5	18	27	7,000
Max.	28.0	28	35	750,000
Min.	6.0	0	12	400
N.S.	7	5	5	7

T-15

	Temp (°C)	Phenols (ug/1)	Chlorides (mg/1)	Total Coliform* (MF/100 ml)
Ave.	13.0	42	40	7,500
Max.	21.0	160	69	140,000
Min.	5.0	0	10	600
N.S.	16	10	8	16

*Median (not average) for bacteriological data.

II. Conclusions

Dredging Operation

The dredging operation causes significant degradation of water quality in the immediate vicinity of the dredge as indicated by increases in concentrations of suspended solids, COD, BOD, total phosphate, volatile suspended solids, and iron. The concentration of these waste constituents generally decreased to substantially lower levels at a distance one half mile downstream from the dredging operation as shown in Figure 9. No pollutional effects of the dredging operation on the Detroit River were detected. Temperature, pH, conductivity, alkalinity, chlorides, phenols, total soluble phosphate, nitrates, nitrite, total coliform, fecal coliform, and dissolved solids did not show measurable increases in the Rouge or Detroit Rivers as a result of dredging the Rouge.

The analysis of the mid-depth samples do not show significant oil pollution. However, the visible film of an oil-solid mixture frequently stirred up behind the dredging operation was not collected as part of the depth samples. Oil films generated by the dredging operation were not of major significance on the Rouge and were not observed at all on the Detroit River.

The dissolved oxygen concentration in the dredging areas decreased with time while the stirred-up material was still suspended in the river. On the dissolved oxygen surveys on October 2 and November 9, decreases of 3 mg/l (in 50 minutes) and 3.5 mg/l (in 34 minutes) respectively, were observed as shown in Figure 6.

Station T18 at Fort St. was sampled during the entire pilot study. Ford Motor Company discharges and the dredging operations are two of the major factors which affect the water quality at this point. Due to the Ford strike the influence of the discharge of this company was the least during the 60-day period commencing on September 8. Six samples were collected at Fort St. during this period. Three samples were collected with the dredging operation upstream and three with the dredging downstream from the bridge. The average of these three samples show only a small increase in certain parameters under the influence of the dredging operation as shown in the following table:

Station T-18
Fort St. Bridge
Average Values

Parameter (mg/l) (average of three values)	Dredging Operation Upstream from Fort St.	Dredging Operation Downstream from Fort St.
COD	24	26
BOD	4	3
Suspended solids	56	50
Volatile susp. solids	9	7
Total phosphates	.94	.71
Iron	5.6	4.0

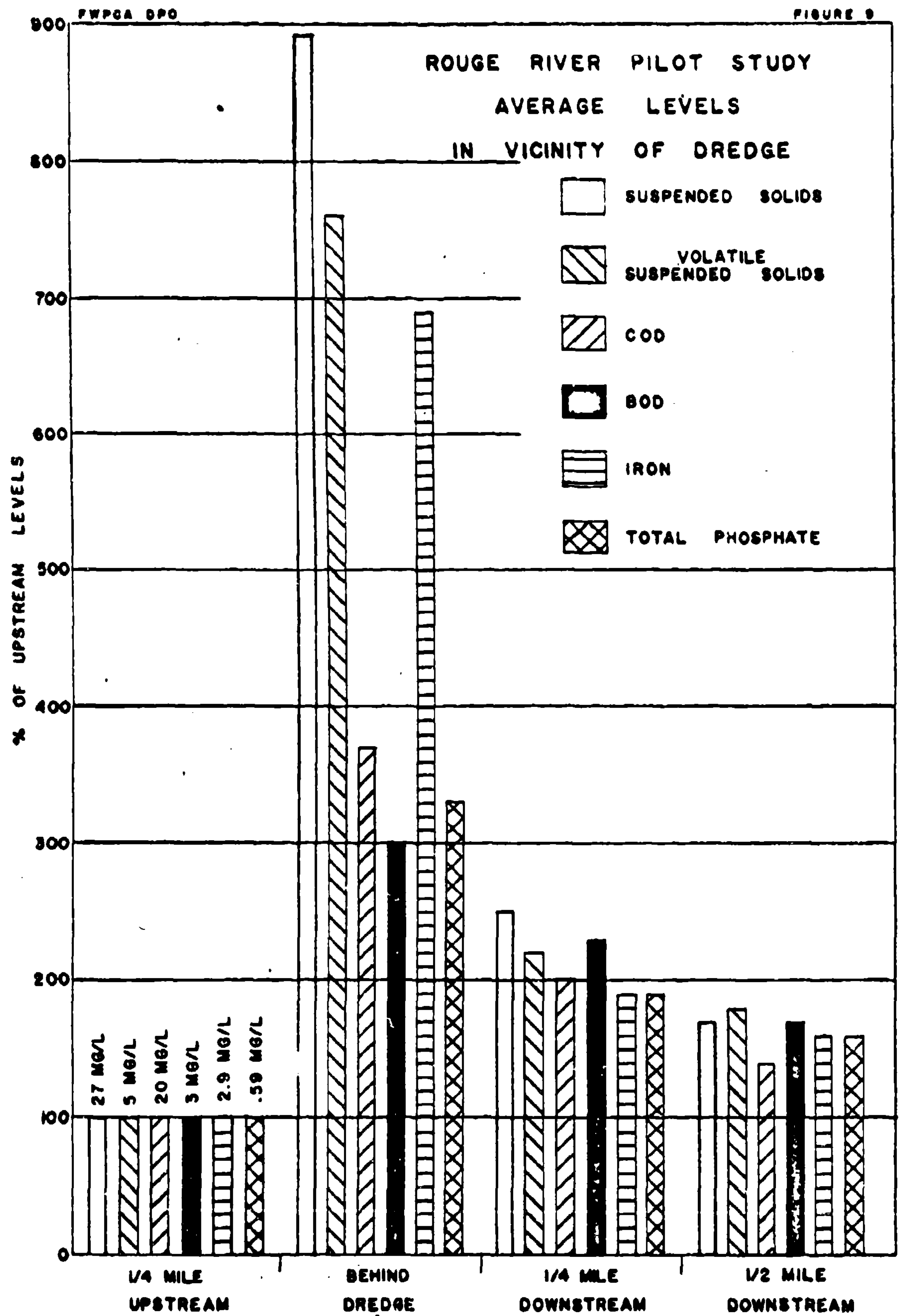
The average solid content of the intake sludge was 38%. The detention of the material in the hoppers provided for 47% removal of the solid material from the sludge before overflow. The dredged sludge was homogenous and the solids contained in the intake and overflow sludge exhibited similar chemical characteristics. The following table lists the average concentrations of several constituents in the dry solid dredged material.

Intake & Overflow
Average Concentration*
mg/kg Dry Basis
(except as noted)

Volatile Solids (% Dry Basis)	18
Total Phosphate	8700
Total Soluble Phosphate	8
Nitrate	60
Nitrite	.3
Ammonia	400
Iron	100
Oil & Grease	40,000
COD	260,000

Both the undisturbed and dredged sediments were found to be highly polluted, exerting high oxygen demand and containing large concentrations of iron, oil and volatile solids. The highest concentrations of oil and iron were found in sediments collected from the Rouge upstream from its intersection with the Old Channel.

*Excluding intake & overflow from the Old Channel


FWPCA DPO
FIGURE 9
ROUGE RIVER PILOT STUDY
AVERAGE LEVELS
IN VICINITY OF DREDGE
SUSPENDED SOLIDS
VOLATILE SUSPENDED SOLIDS
COD
BOD
IRON
TOTAL PHOSPHATE
% OF UPSTREAM LEVELS
900
800
700
600
500
400
300
200
100
0
27 MG/L
5 MG/L
20 MG/L
5 MG/L
2.9 MG/L
.59 MG/L
1/4 MILE UPSTREAM
BEHIND DREDGE
1/4 MILE DOWNSTREAM
1/2 MILE DOWNSTREAM

Dumping Grounds

Sampling st Stations R37, R41, and R43 downstream from Grassy Island showed no appreciable degradation of water quality during the dredging period. Examination of past data records for dredging and non-dredging periods also fail to show consistent changes in water quality.

The measurement of water levels inside the wells on Grassy Island indicate that the seepage rate through the dumping ground dikes is low. Well water levels were found remain near that elevation of the Detroit River. The rate of rise after sampling in water level in well #3 also indicate the low seepage rates typical of clayey subsoils. In the week following the end of the dumping operation, the water level in the pond subsided approximately 1 1/2 inches. At this rate the seepage flow from the island is estimated at less than .2 cfs.

The water collected from the wells was found to be grossly polluted. However, it is expected that many of the pollutional characteristics are imparted to the water by the surrounding soils and that the well water is not necessarily representative of water quality of seepage flow.

The Grassy Island pond acts as a settling and stabilization basin. Results of the analysis of the pond sample indicate a decrease in BOD, COD, total phosphate and suspended solids with time. The quality of the pond water are compared to effluent recommendations or requirements set down by the Public Health Service and the Michigan Water Resources Commission for certain industries and municipalities in the Detroit area. (See Table 12) The concentration of these constituents are comparable to the levels required for other discharges to the Detroit River.

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Table 12
Water Quality
Grassy Island Pond

Parameter	Recommendations or Requirements	Pond Average (4)	Overflow Average (4)
Suspended Solids (mg/l)	50 (1)	47	52
Total Coliform (org/100 ml)	note (3)	12,000	1800
Fecal Coliform (org/100 ml)	note (3)	470	17
Oil (mg/l)	15 (1) (2)	6	3
Phenol (ug/l)	20 (2)	13	9
BOD (5-day) (mg/l)	20 (2)	18	10
pH (standard units)	5.8 - 10.8 (1)	7.7	8.0
Iron (mg/l)	17 (1) (2)	3.8	2.4

(1) Michigan Water Resources Commission stipulation for certain effluents.
(2) U.S. Public Health Service recommendation for certain effluents.
(3) Proposed water quality standard:
Total body contact: The average of any series of 10 consecutive samples shall not exceed 1000 organisms/100 ml nor shall 20% of the samples exceed 5000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 100. This standard applies to the Detroit River except at the mouths of tributaries, and in the immediate vicinity of enclosed harbor areas and waste treatment plant outfalls.
(4) Median for coliform.

III. APPENDIX

Laboratory Procedure

Bottom sediment samples were analyzed according to the Chicago Program Office (FWPCA) procedures and Standard Methods for the Examination of Water and Wastewater, 12th Edition, 1965.

Parameters not run according to the Chicago Program Office procedures are: IDOD, BOD, NO_2, NH_3-N and Organic-Nitrogen. However, the first three of these parameters were run according to "Standard Methods" with modifications and the NH_3-N and Organic-Nitrogen analyses were run according to published procedures.

The following is a condensed procedure for each of these parameters which were run by the Detroit Program Office, FWPCA. Chicago procedures are not listed.

A limited number of precision tests were run on all parameters except BOD, to provide a base for the number of significant figures to which each test is reported.

Immediate Dissolved Oxygen Demand (IDOD) and BOD (5-day) Determinations Using a Dissolved Oxygen Analyzer (D.O. probe)

1. Prepare dilution water at 20°C and measure its oxygen content.
2. Weigh 5-10 grams of sample and siphon in dilution water to fill the BOD bottle.
3. Let stand exactly 15 minutes.
4. Measure oxygen content and report as IDOD based on 10 or 5 grams at 20°C.
5. In addition to the 5-10 gram sample prepare dilutions containing 1 gram and .5 gram of sample. Determine dissolved oxygen content after 15 minutes.

Use the 15 minute oxygen concentrations as initial oxygne content for BOD.

6. Measure oxygen content after five days incubation at 20°C.

Nitrite - Nitrogen (Manual Determination)

1. Weigh 5 grams of sample into 150 ml beaker. Add 50 ml nitriet-free water, and let stand overnight.
2. Filter through membrane filter and analyze according to "Standard Methods."

Determination of Ammonia and Organic Nitrogen following Phenol Analysis Using Cupric Sulfate as Catalyst

Ammonia - Nitrogen (Manual Determination)

1. Place 10 grams of sample into a 1000 ml distilling flask. Add 550 ml phenol-free distilled water and 10 ml of 10% Cu-SO_4-H_3PO_4 solution.
2. Distill over phenol.
3. To the residue in flask, add 5 ml of NAOH (250 g/liter), a few glass beads, and enough water to make 250 ml approximately.
4. Distill over NH_3 in bottles. (Boric Acid is used only for extremely high concentrations).
5. Measure the volume and save for nesslerization.

Organic Nitrogen

1. Add 10-50 ml K_2SO_4-H_2SO_4 solution to the residue from ammonia determination; digest until fumes are acid to litmus paper.
2. Cool; add distilled water to volume of about 250 ml.
3. Add 50% solution of NaOH containing thiosulfate, the volume of which is equal to the amount of K_2SO_4-H_2SO_4 added in Step 1.

4. Distill over NH_3 into bottle. Measure volume and save for nesslerization.

5. Nesslerize NH_3 and organic samples according to "Standard Methods."

Rouge River Water Quality - Ford Motor Company

The 61-day Ford Motor Company strike commenced on September 7. During this period of pollutants by that company were expected to be lower than usual. Samples were collected to determine water quality during the strike period. The results are shown in Table and the averages are shown below

Average Values
Station T-19

		Phenol ug/l	Oil Mg/l	Iron mg/l	Suspended Solids mg/l
Oct. 18 - Nov. 7	Ave.	16	3	3.8	34
	Max.	160*	5	9.0	79
	Min.	5	2	.7	12
	N.S.	12	13	15	14
Nov. 8 - Nov. 24 (except Nov. 16)	Ave.	14	3	6.2	34
	Max.	22	4	13	57
	Min.	10	2	3.0	15
	N.S.	9	10	10	10

The averages show little difference in phenol, oil and suspended solids concentration. However, the affect of Ford Motor Company on the Rouge River should not be underestimated for several reasons.

1. The activities within the Rouge Plant during the official strike period are not known.
2. The pollution caused by stormwater overflow may have masked the effects of Ford.
3. Surface oil is not reflected in depth sample concentration.
4. The Rouge water quality appeared improved during the UAW strike period.
5. Routine freighter activity causes polluted condition as shown by the sample collected on November 16, 1967.

The iron concentration does show a 60% decrease during the strike period.

*Not included in average

The levels of all these contaminants during this period will be compared to similar measurements made in the future.

FWPCA, DPO

Table 13
Rouge River
Station T19
Dix Ave. Bridge
Mid-Depth Samples

Date	Temp. °C	Phenol ug/l	Oil mg/l	Iron mg/l	Suspended Sol. mg/l
10-18 S	15.0	12	4	2.6	79
10-19	12.0	18	4	2.6	-
10-20	12.5	18	3	1.7	26
10-23	12.0	5	2	.7	13
10-24	12.0	160	3	.8	12
10-25	12.5	29	3	.7	16
10-26	12.0	16	3	1.6	17
10-27 S	12.0	14	3	7.6	29
10-30	11.5	8	3	9.0	45
10-31	14.0	18	3	4.8	29
11-1 S	15.0	-	3	5.0	34
11-2	13.5	24	5	4.4	57
11-3 S	14.0	-	3	7.3	47
11-6	10.0	10	5	3.8	30
11-7#	11.5	-	4	4.9	37
11-8	12.0	-	3	3.0	25
11-9	12.0	20	4	3.2	15
11-13 S	11.0	13	2	6.2	37
11-14	12.0	10	3	6.8	23
11-15	11.0	11	2	6.2	28
11-16*	11.0	10	14	46	94
11-17 S	10.5	10	3	7.5	31
11-20	7.5	17	3	5.6	44
11-21	11.0	22	3	4.9	32
11-22	10.0	-	2	13	57
11-24	7.0	17	1	5.4	49

*Passing freighter stirred bottom material
S - Data may reflect stormwater overflows on October 15, 16, 17 and 27 and November 1, 3, 11, 17.
#Strike officially ended on November 7, 1967

Flow Records - Detroit and Rouge Rivers

The flow pattern of the Detroit River, which has an estimated average discharge of 178,000 cfs, is shown in Figure 10 . Variations in flow during the study were not determined. However, an above-average discharge was maintained during the dredging period as shown in the following table.

	Detroit River Average Flow (cfs)
August, 1967	198,000
September, 1967	196,000
October, 1967	194,000
November, 1967	196,000

A portion of the Detroit River flow, estimated at 2800 cfs, is diverted into the upstream end of the Old Channel of the Rouge and returns to the Detroit River by way of the Short - cut Canal. The Short - Cut Canal is an artificial connection from the Detroit River to the natural bend in the Rouge River which eliminates and "S" shaped curve near the mouth.

Discharge measurements are taken by the U.S. Geological Survey at the Lower, Middle and Upper Rouge. The summation of the average discharges of record from these three gages shows an average flow of the Rouge River above the influence of Detroit River backwater of approximately 216 cfs. However, the flow during the autumn months are somewhat lower as indicated in the following table.

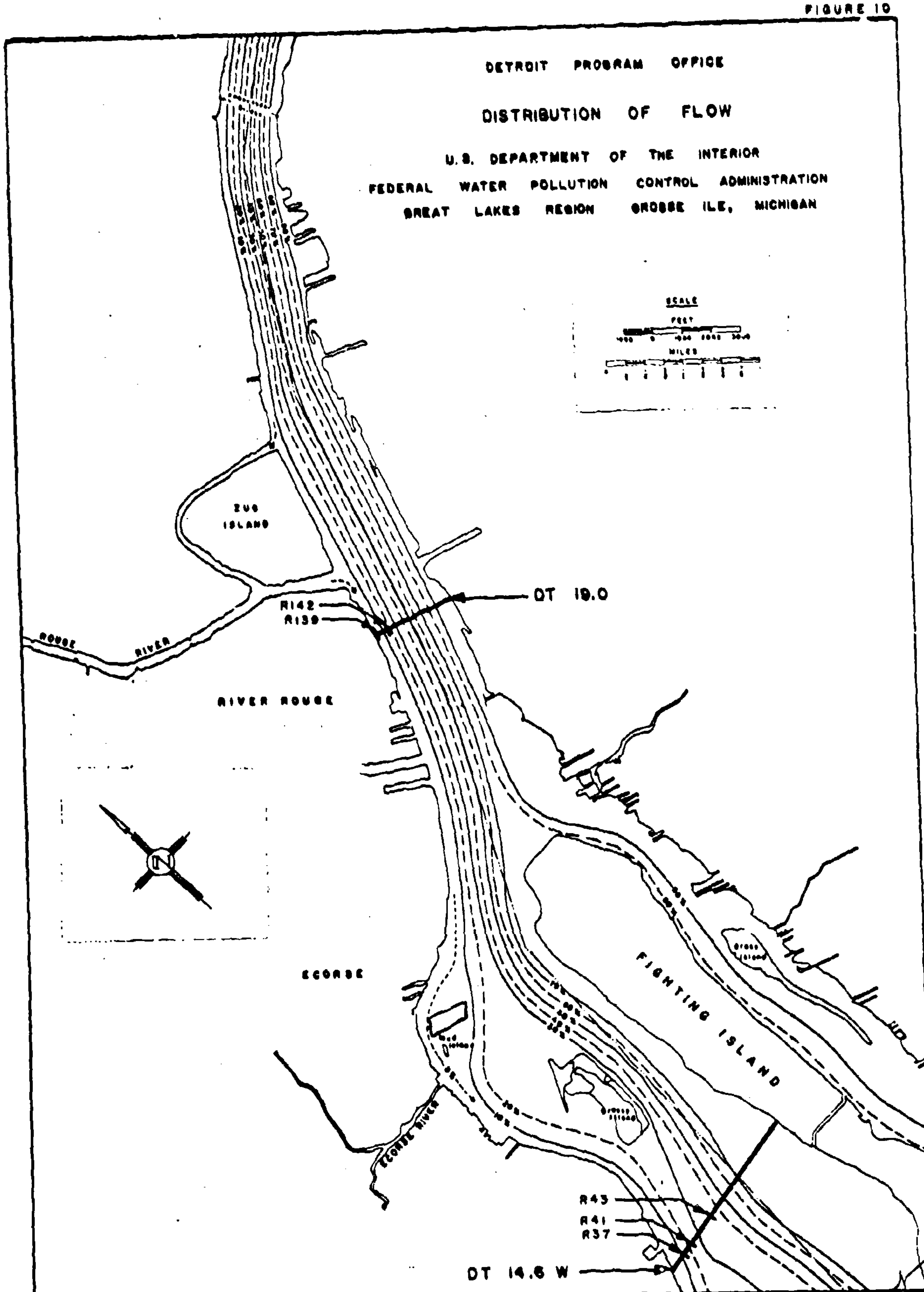
	Average Flow (cfs)
August	64
September	59
October	86
November	120

The flow records for the Rouge River during the 1967 dredging period are not available at this time. However, the streamflow in the Southeastern Michigan basin was in the normal range during the study.

Variations in effluent flow from the Ford Motor Company can cause major changes in the flow in the dredging area. This company discharges an average of more than 600 cfs, of waste and cooling water ten times the average natural September basin yield.

In summary, the flow entering the Detroit River from the Rouge River Short - Cut Channel is effectively the sum of the Rouge River natural yield (average = 216 cfs), the Ford Motor Company discharge (average = 600 cfs), and the Old Channel flow (average = 2800 cfs).

FIGURE 10


DETROIT PROGRAM OFFICE
DISTRIBUTION OF FLOW
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION GROSSE ILE, MICHIGAN
SCALE
FEET
MILES
ZUG ISLAND
R142
R139
DT 19.0
ROUGE RIVER
RIVER ROUGE
ECORSE
ECORSE RIVER
FIGHTING ISLAND
R43
R41
R37
DT 14.6 W

Attached is a list of lab numbers as used in the Rouge River Pilot Study report.

Rouge River Pilot Study 1967

PARAMETER: **Lab. No.**

Date	Dredge Loc. (mile points)	1/4 Mile Upstream	Behind Dredge	1/4 Mile Downstream	1/2 Mile Downstream	Rouge R. T18 (MP 2.19)	Rouge R. T15 (MP 1.09)	Detroit R. R139	Detroit R. R142
8-24	None	-	-	-	-	34553	34554	34551	34552
8-31	2.67 to 2.94	-	35500	35501	35502	-	-	-	-
9-7	2.55 to 2.94	36527	-	36529	36526	36526	36525	36523	36524
9-14*	2.40 to 3.00	-	37523	37524	37525	37527	37526	37521	37522
9-21*	1.93 to 2.63	38524	38523	385[illegible]	38522	38525	38526	38527	38528
10-5*	1.87 to 2.69	-	40547	40545	40546	40544	40543	40541	40542
10-12*	1.50 to 2.17	41525	41526	41523	41524	41528	41527	41521	41522
10-19*	1.45 to 2.17	42554	42560	42555	42556	42553	42552	42557	42558
10-29	Old Channel	44500	44501	44502	-	-	-	44504	44505
11-8*	0.87 to 1.46	45534	45536	45533	45535	45532	45531	45537	45530

APPENDIX A

REPORT ON

THE EFFECTS OF DISPOSAL OF DREDGING

SPOIL FROM INDIANA HARBOR CANAL INTO THE

INLAND STEEL COMPANY'S LANDFILL LAGOON

NOVEMBER 1967

Federal Water Pollution Control Administration
Great Lakes Region
Chicago Program Office

TABLE OF CONTENTS

INTRODUCTION

The United States Army Corps of Engineers received permission from the State of Indiana and Inland Steel Company to dispose of dredging spoil from the Indiana Harbor Canal in Inland Steel Company's landfill lagoon during October 1967. At the request of the Corps of Engineers and the State of Indiana, the Federal Water Pollution Control Administration, Chicago Program Office, established a surveillance program in the area. This program was carried out with the cooperation of the Corps of Engineers which made the tugboat "Moore" available for sampling runs and assisted in every way. The purpose of the surveillance was to determine the effect of pollution of Lake Michigan resulting from the disposal of the spoil into the lagoon.

The 82 acre lagoon is formed by a concrete filled sheet steel coffer dam which has been backfilled to a distance of 50 to 100 feet with slag (see map, page 5). The coffer dam and slag fill is impervious except for a 150 foot wide gap which opens to Lake Michigan. The depth in the gap was dredged to 12-14 feet in order to bring the loaded barges into the lagoon. It was feared that pollution would escape through this gap and be carried to one of the five public water intakes which are located in the vicinity (see map, page 4).

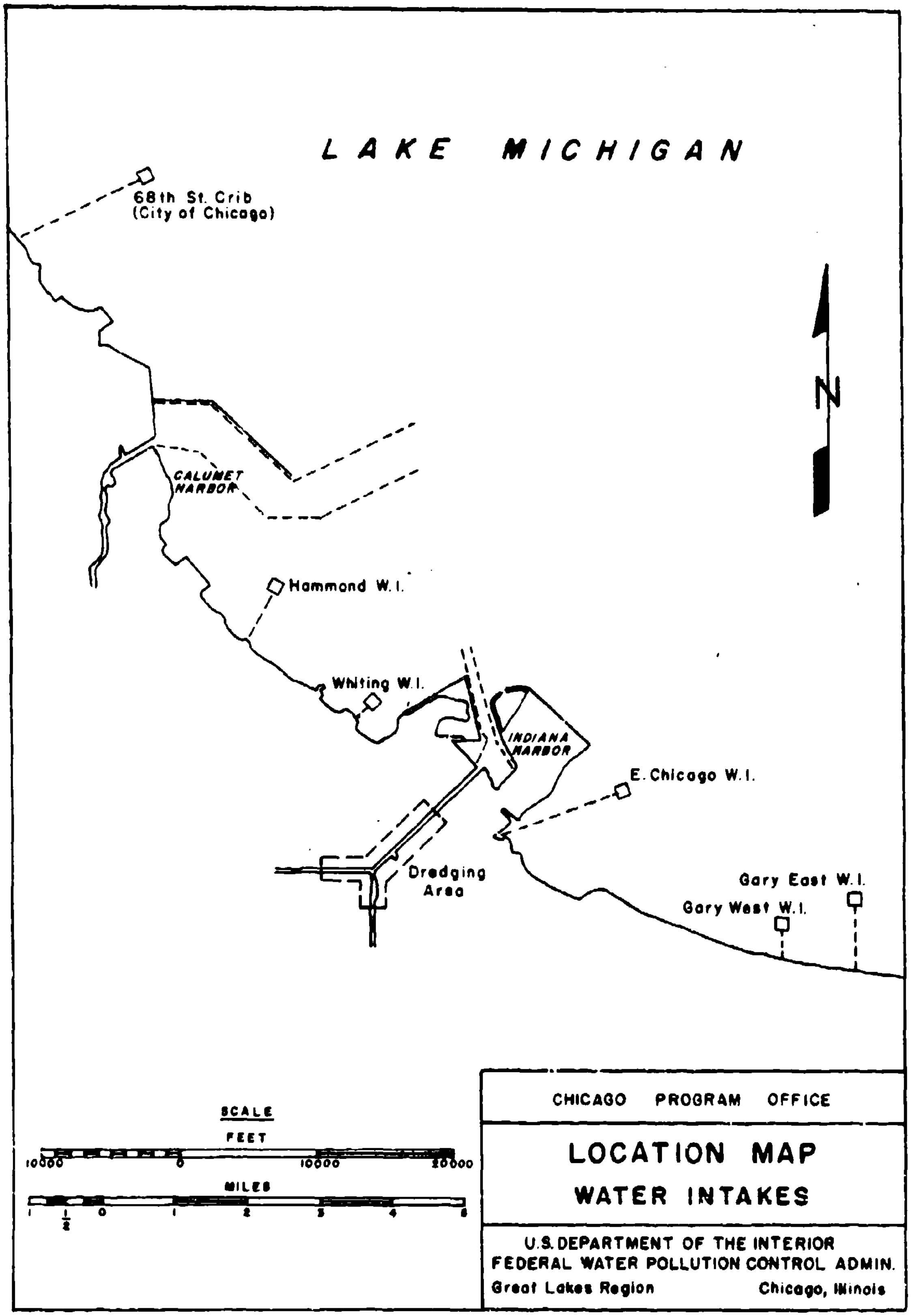
CONCLUSIONS

1. No heavy materials escaped from the lagoon to contaminate the bottom of the lake.

2. Water quality within 1/4 mile of the gap was noticeably affected but, at more distant points, contamination from the lagoon was negligible compared with contamination from Indiana Harbor.

3. The lagoon was filled with less than 1 foot of material and the bottom is still 6-7 feet below the level of the sill. The lagoon can be used for spoil disposal at the rate of 120,000 cu. yds. per year for several years. Surveillance should be maintained during the disposal operation to insure that severe pollution to the lake does not occur.

4. The bubbler system installed by the Corps of Engineers to prevent surface contamination was not effective because the amount of air was insufficient to create vertical currents when a south wind caused a strong surface current through the gap.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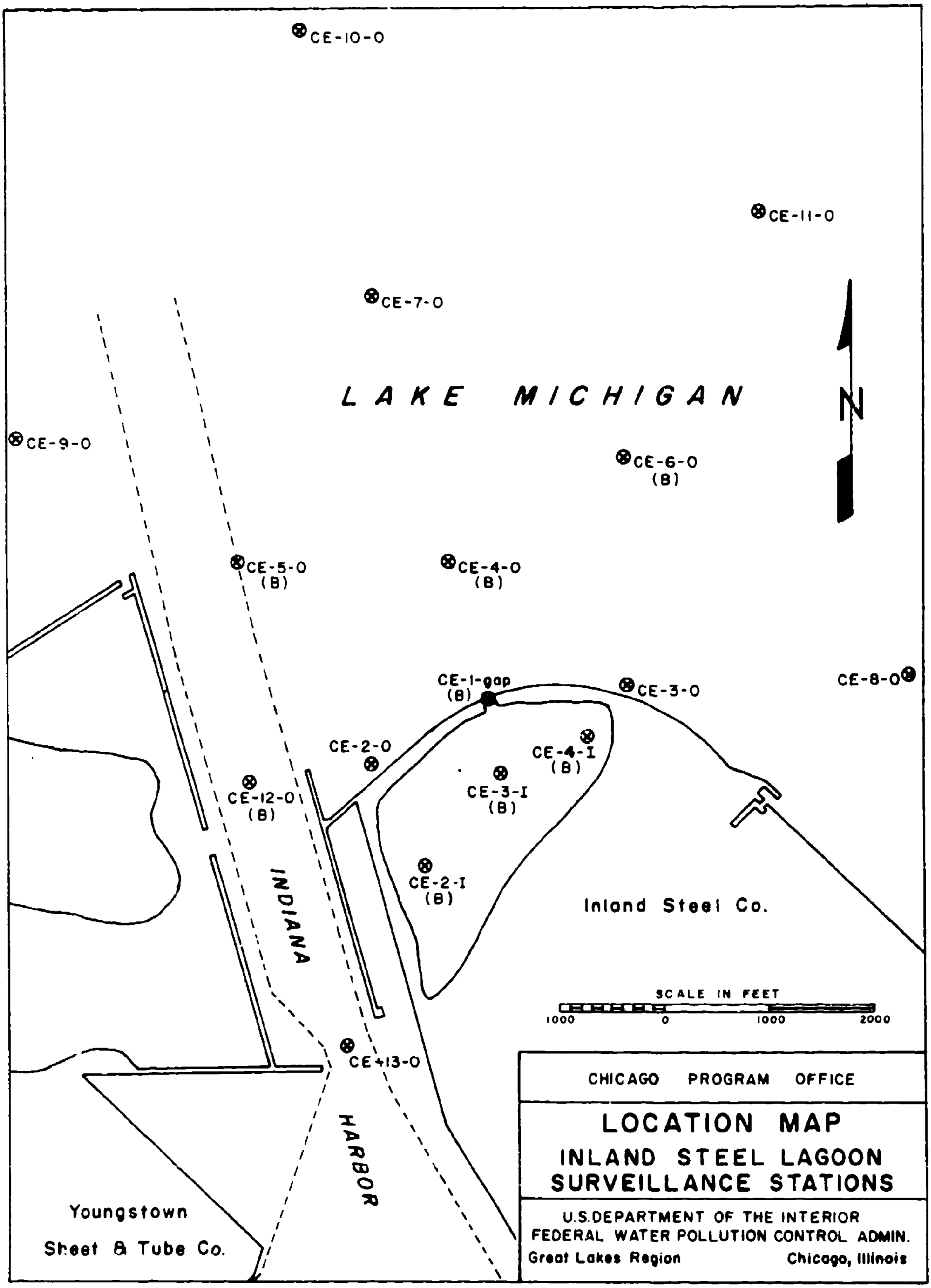
(City of Chicago)
CALUMET HARBOR
Hammond W.I.
Whiting W.I.
INDIANA HARBOR
E. Chicago W.I.
Dredging Area
Gary East W.I.
Gary West W.I.
N
SCALE
FEET
10000
0
10000
20000
MILES
1
1/2
0
1
2
3
4
5
CHICAGO PROGRAM OFFICE
LOCATION MAP
WATER INTAKES
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois


CE-10-O
CE-11-O
CE-7-O
LAKE MICHIGAN
N
CE-9-O
CE-6-O (B)
CE-5-O (B)
CE-4-O (B)
CE-1-gap (B)
CE-3-O
CE-8-O
CE-2-O
CE-4-I (B)
CE-12-O (B)
CE-3-I (B)
INDIANA
CE-2-I (B)
Inland Steel Co.
SCALE IN FEET
1000 0 1000 2000
CE-13-O
HARBOR
Youngstown
Sheet & Tube Co.
CHICAGO PROGRAM OFFICE
LOCATION MAP
INLAND STEEL LAGOON
SURVEILLANCE STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois

CHRONOLOGY OF EVENTS

October 14, 1967 - The Inland Steel Company granted permission for the use of its existing landfill lagoon as a disposal site for spoil dredged from the Indiana Harbor Canal.

October 26, 1967 - The Indiana Stream Pollution Control Board objected to the use of the lagoon on the grounds that contaminated materials escaping from the lagoon might endanger public water supplies located within a few miles of the lagoon (see map, page 4).

November 2, 1967 - The Indiana Stream Pollution Control Board withdrew its objection upon being assured that the Federal Water Pollution Control Administration would monitor the area to detect pollution escaping from the lagoon and that the Corps of Engineers would take appropriate action to prevent such pollution.

November 6, 1967 - The first barge loads of spoil were dumped into the lagoon. Personnel of the Calumet Area Surveillance Unit of the Chicago Program Office collected six water samples, including one inside the lagoon, before the first barge was dumped. A sample was also collected in the discolored area caused by the dumping. Buoys were placed by the Corps of Engineers to mark the open water sampling stations.

November 7, 1967 - Fourteen stations were sampled for water quality and six for bottom mud, using the buoys placed by the Corps of Engineers. No unusual conditions were observed.

November 16, 1967 - Two employees of the Chicago Program Office rode one of the barges and collected water samples inside the gap, outside the gap and in the disposal area. Oil was observed leaving the lagoon. The wind was from the south.

November 20, 1967 - Daily observation of the lagoon by Chicago Program Office personnel was initiated. A barge was observed leaving the lagoon and causing a long wake of discolored water in the lake which extended to the Indiana Harbor channel. It was determined that the wake was due to the fact that the barges were required to stop in the lagoon during dumping, therefore there was no washing action on the hoppers. It was agreed that all barges were to make a full 360 degree circle around the lagoon after dumping to provide washing action inside the lagoon. No further discolored wakes were observed in the lake.

November 21, 1967 - All fourteen stations were sampled. Heavy oil was observed on the lagoon and a considerable slick extended from the gap out into the lake for more than a mile. There was no oil coming from Indiana Harbor. The wind was from the south and had been for several days.

November 22, 1967. Wind northwest. Oil was observed on lagoon but none on lake or harbor.

November 24 and 27, 1967 - Wind strong from the north. Lake too rough for barges. No spoil dumped.

November 28, 1967 - Sampling run attempted but lake too rough. Three stations were sampled. Wind was strong from west.

November 29, 1967 - Twelve stations were sampled for water quality and six for bottom muds. Wind was light from southeast. Oil observed on lagoon and harbor but little on lake. Corps of Engineers personnel began collecting water samples for turbidity analysis as barges entered and left the lagoon. Bottles were supplied by the Chicago Program Office for this purpose. The Corps of Engineers began operating a bubblersystem across the gap with the purpose of preventing the flow of oil and pollution through the gap.

December 1, 1967 - Fourteen stations were sampled for water quality and six for bottom muds. Wind was strong from the south. The Corps of Engineers was working on the bubbler to increase its air capacity. Oil was observed on the lake for a distance of 1/2 mile from the gap.

December 5, 1967 - Fourteen stations were sampled for water quality and six for bottom muds. Wind was light from the south. The bubbler was operating but did not appear to be effective. The water was the same color on both sides of it. It was not strong enough to cause the rolling action necessary to keep the water from mixing.

December 12, 1967 - Fourteen stations were sampled for water quality and six for bottom muds. Wind was strong from the west. Oil was observed on the harbor and the lagoon but little on the lake.

December 13 and 14, 1967 - Winds strong from north, lake too rough for barges, no spoil discharged.

December 16, 1967 - Dredging completed, last barge dumped.

December 18, 1967 - The lagoon was inspected to determine if further operation of the bubbler was required. The bubbler was not operating due to a mechanical failure in the compressor. There was a plume of discolored water extending several hundred yards into the lake from the gap. The wind was moderate, from the south. It was decided to put the bubbler back in operation for three days or until the next period of prolonged northerly winds.

DISCUSSION OF RESULTS

Bottom Sediments

The results of the physical observations of the bottom sediments show that very little, if any, of the heavy organic matter escaped from the lagoon. Samples taken at Stations CE-4-0, CE-5-0, and CE-6-0 (see table 1 page 10) were predominantly clean sand or gravel. On December 5, 1967 some organic material was found at Stations CE-4-0 and CE-5-0 but there is reason to believe that this came from the harbor and not the lagoon. Samples taken at Station CE-12-0 show that there is considerable contamination of the bottom originating in Indiana Harbor. Six samples taken in the gap produced no organic material. The current through the gap keeps it scoured clean. On December 18, 1967, a rough measurement of this current was made by allowing a boat to drift through the gap. It drifted 50 yards in 2.5 minutes, or one foot per second. The wind was moderate, from the south. On December 12, 1967, the bottom immediately outside of the gap was examined by sampling 20, 50 and 100 yards from the gap. At 20 yards the bottom consisted of large rocks 15 feet deep, probably rubble from the construction of the breakwater. At 50 and 100 yards the bottom was clean sand about 24' deep with no evidence of contamination. All samples taken inside the lagoon consisted of heavily polluted black, oily material similar to that found in the dredge hopper.

Before the dumping began the lagoon was 23 to 25 feet deep. A total of 120,000 cubic yards of spoil was deposited in the lagoon, producing an average thickness of 0.9 feet.

$$\frac{120{,}000 \text{ cu.yd.} \times 27 \text{ cu.ft./cu.yd.}}{43{,}560 \text{ sq.ft./acre} \times 82 \text{ acres}} = 0.9 \text{ feet}$$

TABLE 1

INLAND STEEL LAGOON SURVEILLANCE
Summary of Field Observations of Bottom Samples

11/7/67	CE 1-0 gap	14' deep - black gravel, mostly slag, no odor, little evidence of organics
	CE 2-I	22' deep - black silt, slight oil odor
	CE 4-0	32' deep - 3 pieces of tan gravel, 2 dips
	CE 5-0	30' deep - sand, no odor
	CE 6-0	26' deep - sand, no odor
11/21/67	CE 1-0 gap	13' deep - one large piece of slag, 2 dips
	CE 4-I	19' deep - black silt, very oily, petroleum odor
	CE 3-I	20' deep - black ooze, very oily, petroleum odor
	CE 4-0	30' deep - gravel, no odor
	CE 6-0	26' deep - sand, no odor
	CE 12-0	28' deep - sand, some silt, slight oil odor
11/29/67	CE 1-0 gap	hard bottom, no sample, 3 dips (No field notes. Examined frozen samples and questioned samplers.)
	CE 2-0	sand
	CE 4-0	sand
	CE 12-0	sandy black silt
12/1/67	CE 1-0 gap	14' deep - hard bottom, no sample, 3 dips
	CE 3-I	19' deep - black ooze, oily petroleum odor
	CE 4-0	31' deep - sand and gravel, no odor
	CE 5-0	31' deep - sand, no odor
	CE 12-0	27' deep - black ooze, some sand, slight petroleum odor
12/5/67	CE 1-0 gap	13' deep - hard bottom, no sample, 3 dips
	CE 4-I	20' deep -black ooze, very oily
	CE 4-0	30' deep - sand, black oily material, slight petroleum odor
	CE 5-0	30' deep - sand, some black material, no odor
	CE 6-0	25' deep - sand
	CE 12-0	26' deep - black silt, some sand, slight petroleum odor
12/12/67	*CE 1-0 gap	14' deep - hard bottom, no sample, 3 dips
	Outside gap 20 yds	14'-16' deep - large rocks, 3 dips
	*Outside gap 50 yds	24' deep - sand, no odor
	Outside gap 100 yds	23' deep - sand, no odor
	*CE 3-I	22' deep - black silt, very oily, petroleum odor
	CE 4-0	30' deep - sand and gravel
	CE 5-0	31' deep - sand and gravel, no odor
	CE 6-0	24' deep - hard bottom, no sample, 3 dips
	CE 12-0	28' deep - dark grey oily muck, some sand, petroleum odor

* Selected for chemical analysis
See Appendix A

Soundings in the lagoon after the dumping showed a depth of 19-22 feet, confirming the calculation. The sill of the gap is 13-15 feet deep which means the present bottom of the lagoon is 6-7 feet below the sill. At the present rate of disposal (120,000 cu. yds per year) it would take approximately 8 years to fill the lagoon to the level of the sill. Therefore the lagoon can be used for spoil disposal for several years. Surveillance should be maintained during the disposal operations to detect any serious lake pollution that might result.

Water Quality

The results of analysis of the water samples show that the disposal of spoil in the lagoon caused a local deterioration of water quality around the gap but did not cause a wide spread effect that could be detected at the water intakes. Figures 1 thru 10 on pages 15 thru 24 show that flow through the gap had a considerable effect on suspended solids, oil and grease, ammonia nitrogen, organic nitrogen, and total phosphorus; little effect on dissolved solids, dissolved phosphorus, turbidity and pH; and no effect at all on nitrite-nitrate nitrogen.

The nitrogen balance (high ammonia, high organic nitrogen and low nitrite-nitrate nitrogen) is to be expected in water freshly contaminated by organic material that has recently been in an anaerobic state.

The phosphorus and solids results indicate that the spoil is largely insoluble. Figures 5 thru 8 show that total phosphorus and suspended solids were affected far more than dissolved phosphorus and dissolved solids. This is to be expected from spoil taken from the bottom of a flowing stream.

On November 21 and December 1, 1967, considerable amounts of oil were found on the lake coming from the gap. Figure 9 on page 23 shows that a considerable amount of oil and grease originated in the lagoon. This was expected due to the oily nature of the spoil.

The Corps of Engineers attempted to contain the floating oil by installing a perforated hose across the inside of the gap and pumping air through it. This created a curtain of rising air bubbles causing vertical currents which would keep the oil and polluted material inside the lagoon from crossing the curtain. It was not effective except on calm days. On several days, when a south wind was blowing oil was observed on both sides of the bubbler and there was no difference in the appearance of the water inside and outside of the bubbler. The volume of air was not sufficient to create the necessary vertical currents when the wind caused a horozontal current through the gap.

Figures 1 thru 10 are based on average figures for each parameter at each station (see Table 2 page 14). The individual results for each station appear in Tables 3 thru 16 on pages 25 thru 38 . These results indicate a slight increase in contamination with time but the trend is not statistically reliable.

Wind direction has a great influence on local water quality at any particular time. South and east winds cause a discolored plume from Indiana Harbor which is evident beyond Station CE-10-0 but leaves the water around the gap clear. North and west winds cause the discoloration to blanket the area around the gap. Northerly winds tend to restrict and concentrate wastes from the harbor so that some of the highest concentrations were found during periods of north winds.

Table 2 shows that average concentrations of all parameters except turbidity and oil and grease were higher at the mouth of the harbor (Sta. CE-12-0) than at the gap (Sta.CE-1 gap). Since the flow from the harbor is much greater than the flow from the gap it is evident that far more contamination comes from the harbor than from the gap. Except for the area within 1/4 mile of the gap, the effect of contamination from the gap was negligible when compared with contamination from the harbor.

The results of the analyses of the bottom sediments also indicate that pollution from the gap was negligible when compared to pollution from the harbor. Appendix A shows that concentrations of COD, nitrogen, phosphorus, phenol, oil and grease, cyanide and sulphide were very low 50 yards outside of the gap when compared with material from the lagoon. Concentrations of iron, copper, zinc, lead and chromium 50 yards outside of the gap were all comparable to or higher than concentrations inside the lagoon. These concentrations were also very high at Station CE 12-0, which is at the mouth of the harbor. This indicates that most of the pollution 50 yards outside of the gap originated in the harbor and very little originated in the lagoon.

TABLE 2

INLAND STEEL LAGOON SURVEILLANCE

All Stations - Average Values

Station	Temp. °C	pH	NO_2-NO_3-N - mg/1	NH_3-N mg/1	Org.N mg/1	Sol.P mg/1	Tot.P mg/1	COD mg/1	Dis. Solids mg/1	Susp. Solids mg/1	Oil & grease mg/1	Turb. units
1-0 gap	5	8.1	0.28	0.63	0.44	0.018	0.052	10.2	192	15	0.8	6.4
2-0	6	8.0	0.32	0.50	0.40	0.017	0.035	11.2	188	11	0.6	5.4
3-0	6	8.3	0.22	0.35	0.35	0.018	0.033	5.9	178	11	0.7	5.0
4-0	6	8.0	0.22	0.49	0.29	0.016	0.036	9.9	179	9	0.6	4.8
5-0	7	8.0	0.23	0.49	0.27	0.019	0.039	9.5	193	8	0.5	4.8
6-0	4	8.4	0.15	0.18	0.23	0.013	0.023	15.8	166	9	0.4	3.9
7-0	5	8.1	0.24	0.39	0.26	0.013	0.032	8.7	181	8	0.3	2.8
8-0	5	8.1	0.21	0.24	0.18	0.016	0.027	9.4	172	9	0.4	3.2
9-0	4	8.0	0.17	0.20	0.24	0.014	0.026	15.4	168	6	0.6	4.0
10-0	4	8.3	0.15	0.20	0.27	0.011	0.021	10.1	168	7	0.2	3.1
11-0	4	8.5	0.12	0.10	0.18	0.012	0.022	14.0	163	11	0.3	3.6
12-0	9	7.5	0.35	1.16	0.44	0.021	0.057	17.7	225	11	0.5	5.2
13-0	11	7.4	0.42	1.49	0.47	0.023	0.073	13.7	277	11	0.8	7.8
Inside Lagoon	6	8.7	0.23	1.17	0.36	0.019	0.081	18.0	201	40	1.0	8.8

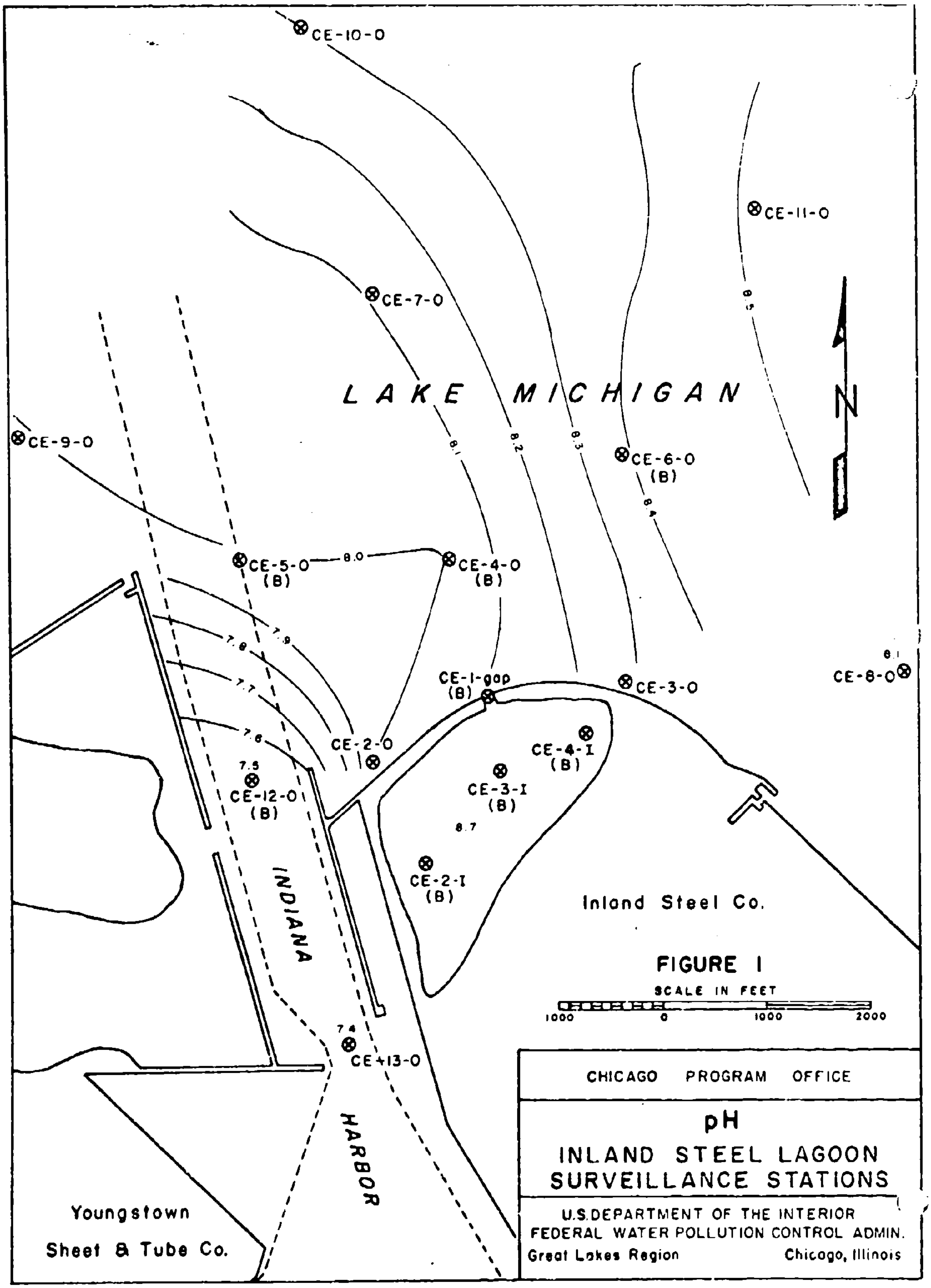


FIGURE I

CHICAGO PROGRAM OFFICE

pH

INLAND STEEL LAGOON SURVEILLANCE STATIONS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region Chicago, Illinois

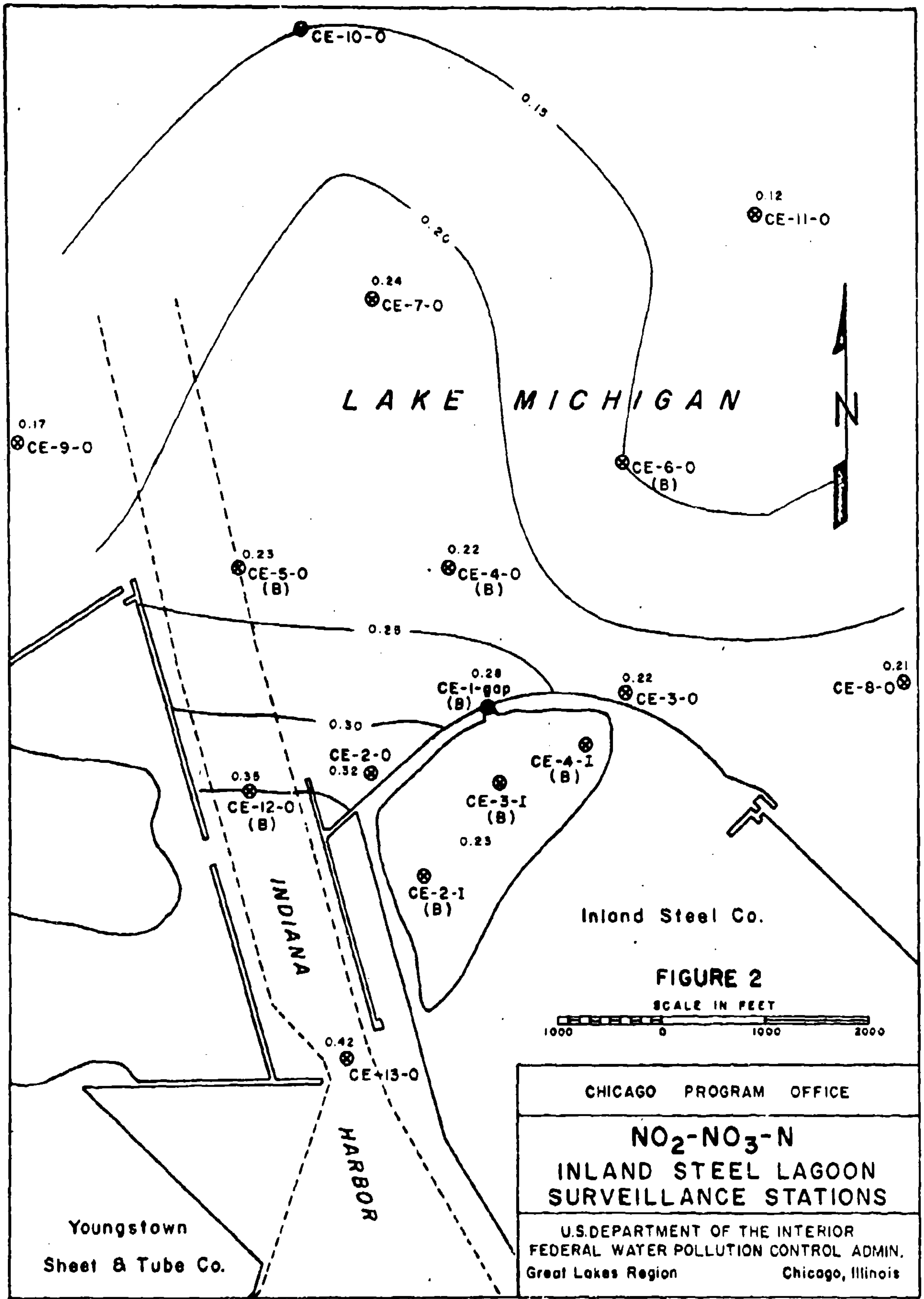

CE-10-0
0.15
0.20
0.12
CE-11-0
0.24
CE-7-0
LAKE MICHIGAN
N
0.17
CE-9-0
CE-6-0
(B)
0.23
CE-5-0
(B)
0.22
CE-4-0
(B)
0.28
0.28
CE-1-gap
(B)
0.22
CE-3-0
0.21
CE-8-0
0.30
CE-2-0
0.32
CE-4-I
(B)
0.35
CE-12-0
(B)
CE-3-I
(B)
0.23
INDIANA
CE-2-I
(B)
Inland Steel Co.
SCALE IN FEET
1000
0
1000
2000
0.42
CE-13-0
HARBOR
Youngstown
Sheet & Tube Co.
CHICAGO PROGRAM OFFICE
NO2-NO3-N
INLAND STEEL LAGOON
SURVEILLANCE STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois

FIGURE 2

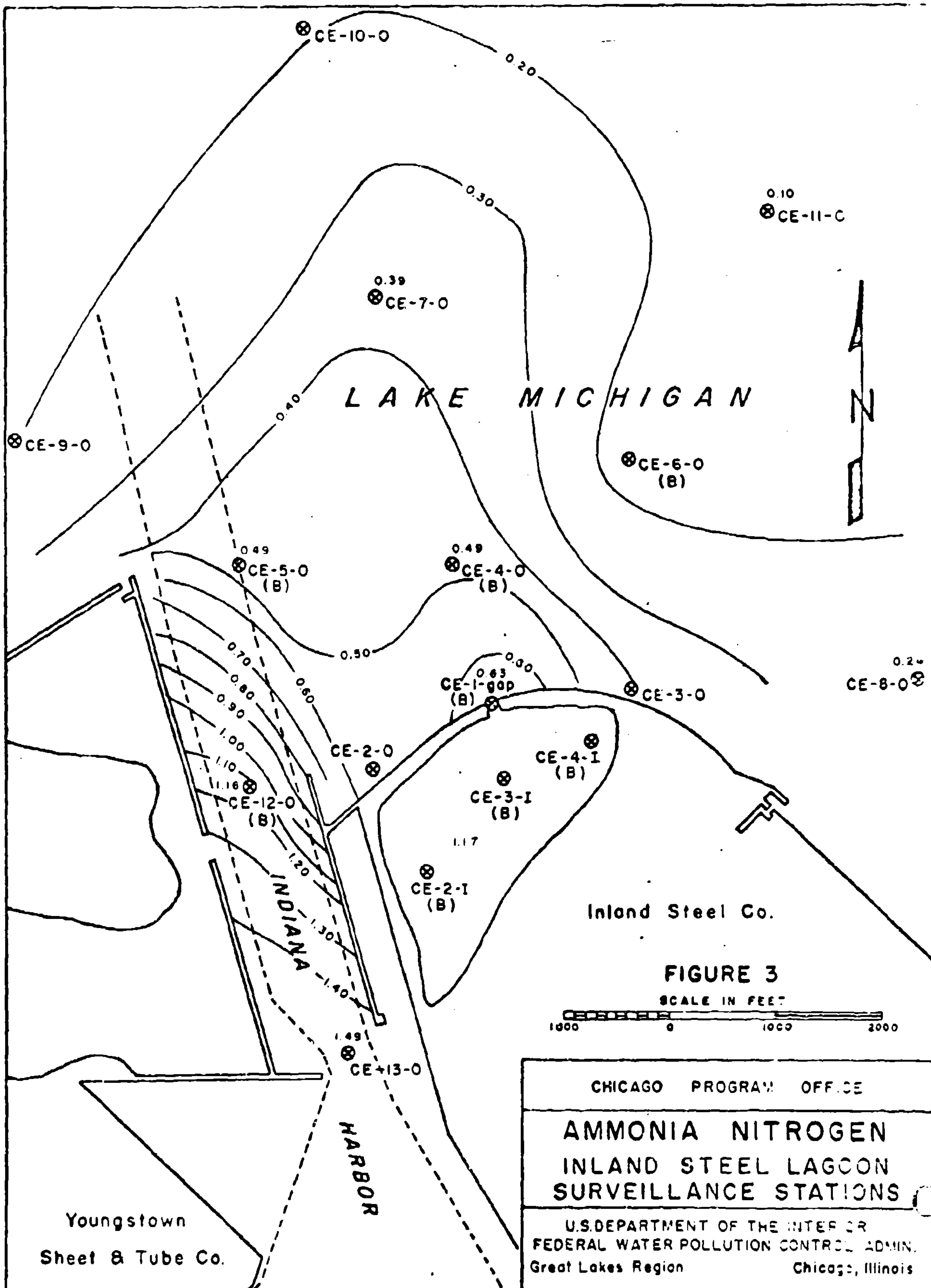
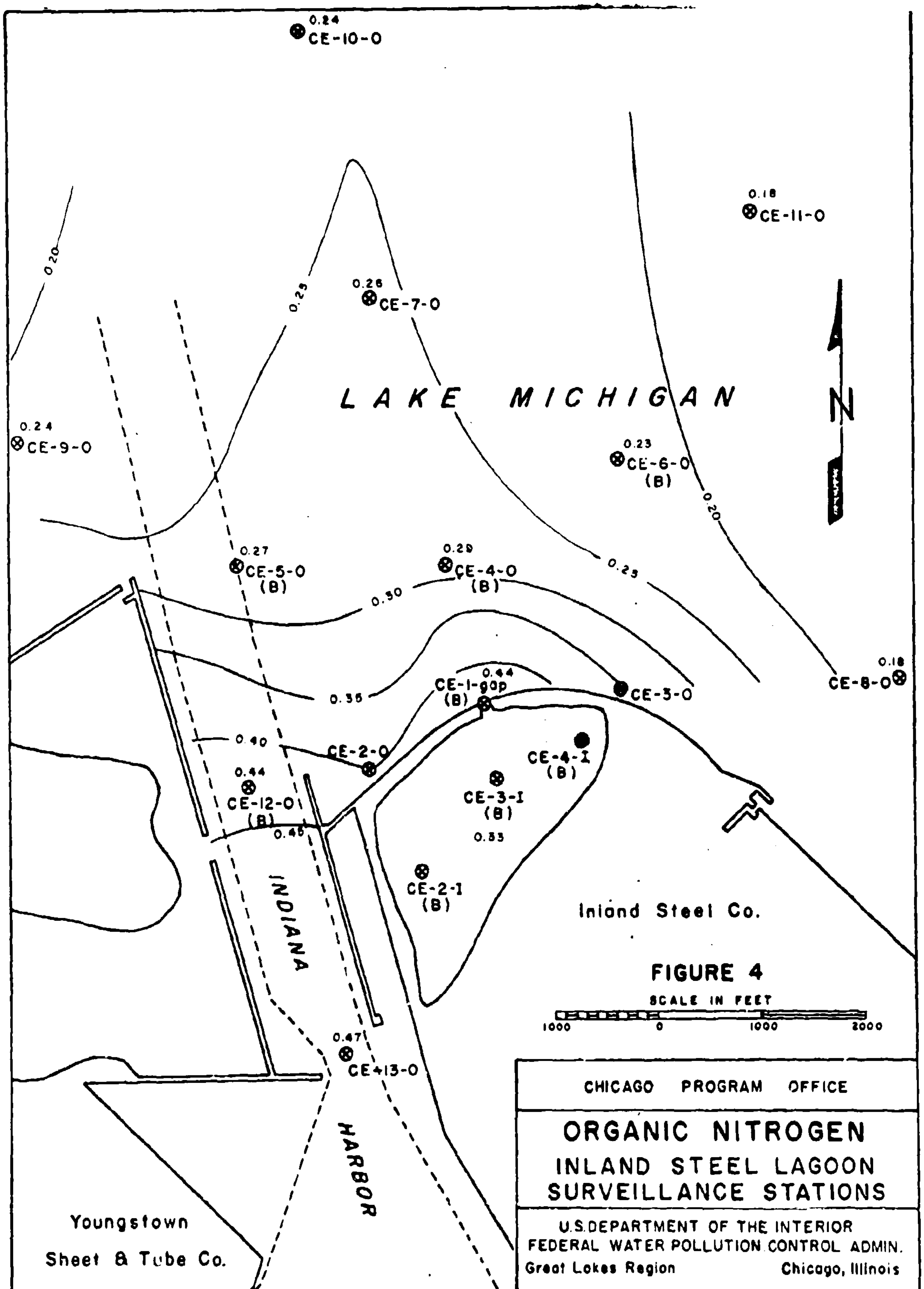


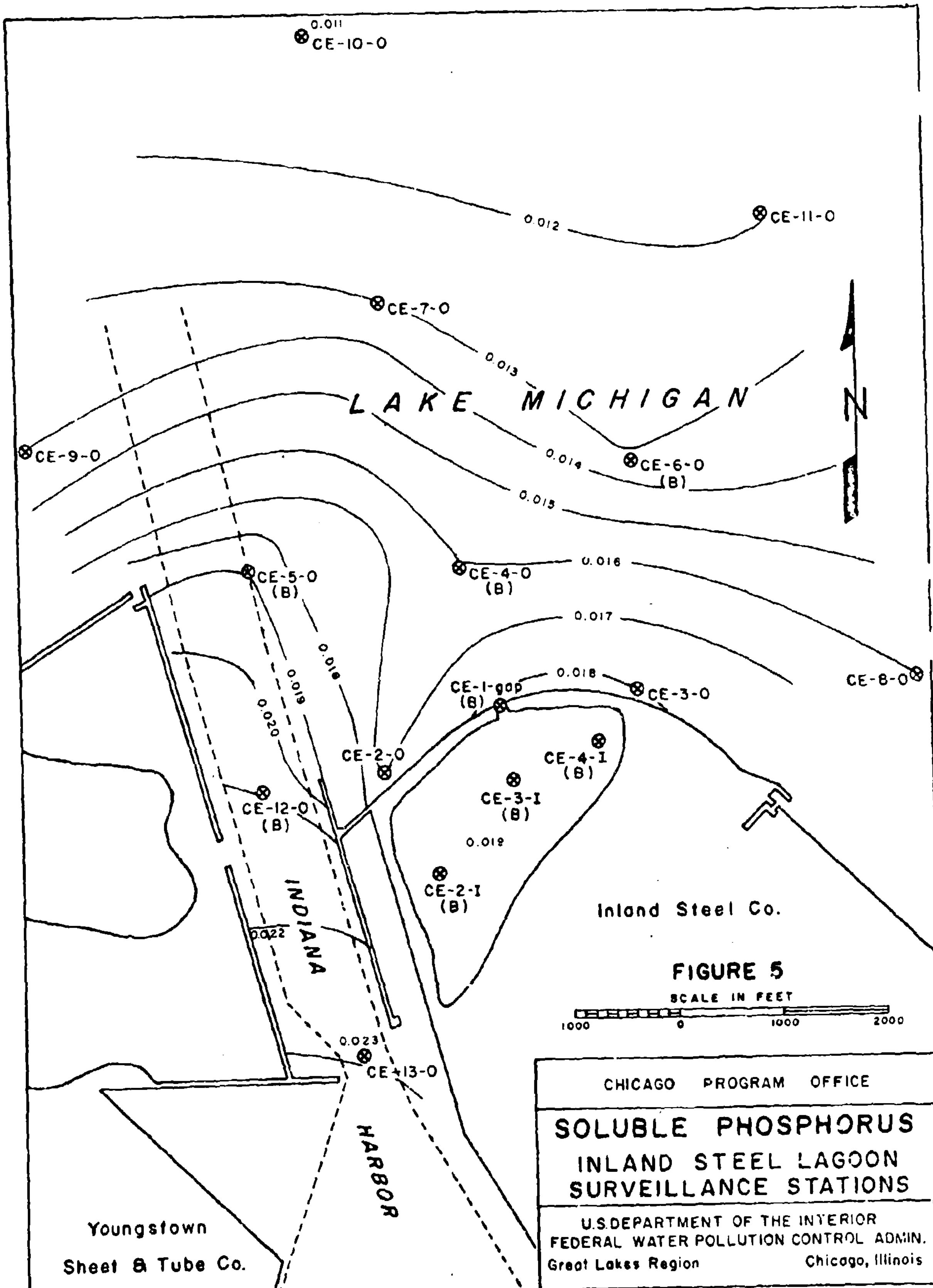
FIGURE 3

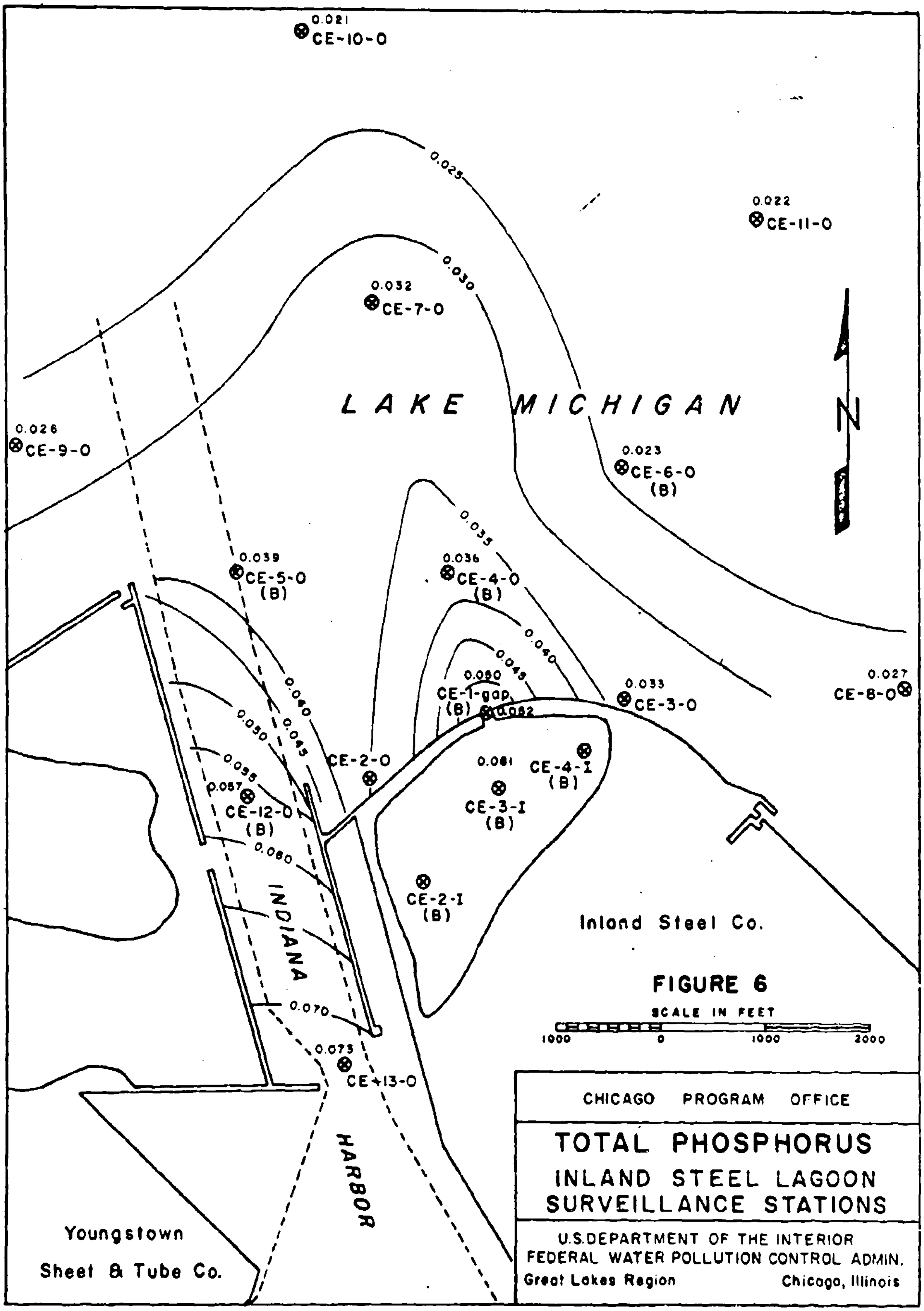
CHICAGO PROGRAM OFFICE

AMMONIA NITROGEN
INLAND STEEL LAGOON
SURVEILLANCE STATIONS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region Chicago, Illinois


0.24
CE-10-0
0.18
CE-11-0
0.26
CE-7-0
0.20
0.25
LAKE MICHIGAN
N
0.24
CE-9-0
0.23
CE-6-0
(B)
0.20
0.27
CE-5-0
(B)
0.29
CE-4-0
(B)
0.25
0.30
0.35
0.44
CE-1-gop
(B)
CE-3-0
0.18
CE-8-0
0.40
CE-2-0
CE-4-I
(B)
0.44
CE-12-0
(B)
0.45
CE-3-I
(B)
0.33
CE-2-I
(B)
INDIANA
Inland Steel Co.
FIGURE 4
SCALE IN FEET
1000
0
1000
2000
0.47
CE-13-0
HARBOR
Youngstown
Sheet & Tube Co.
CHICAGO PROGRAM OFFICE
ORGANIC NITROGEN
INLAND STEEL LAGOON
SURVEILLANCE STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois


0.011
CE-10-0
0.012
CE-11-0
CE-7-0
0.013
LAKE MICHIGAN
N
CE-9-0
0.014
CE-6-0 (B)
0.015
CE-5-0 (B)
CE-4-0 (B)
0.016
0.017
0.018
CE-1-gap (B)
CE-3-0
CE-8-0
0.019
0.020
CE-2-0
CE-4-I (B)
CE-3-I (B)
CE-12-0 (B)
0.019
CE-2-I (B)
INDIANA
0.022
Inland Steel Co.
0.023
CE-13-0
HARBOR
Youngstown Sheet & Tube Co.
SCALE IN FEET
1000 0 1000 2000
CHICAGO PROGRAM OFFICE
SOLUBLE PHOSPHORUS
INLAND STEEL LAGOON
SURVEILLANCE STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois
FIGURE 5



0.021 CE-10-0
0.025
0.030
0.022 CE-11-0
0.032 CE-7-0
LAKE MICHIGAN
N
0.026 CE-9-0
0.023 CE-6-0 (B)
0.035
0.039 CE-5-0 (B)
0.036 CE-4-0 (B)
0.040
0.045
0.050 CE-1-gap (B)
0.052
0.033 CE-3-0
0.027 CE-8-0
0.040
0.045
0.050
0.055
CE-2-0
0.081 CE-3-I (B)
CE-4-I (B)
0.057 CE-12-0 (B)
0.060
INDIANA
CE-2-I (B)
Inland Steel Co.
0.070
0.073 CE-13-0
HARBOR
Youngstown Sheet & Tube Co.
FIGURE 6
SCALE IN FEET
1000 0 1000 2000
CHICAGO PROGRAM OFFICE
TOTAL PHOSPHORUS
INLAND STEEL LAGOON
SURVEILLANCE STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois

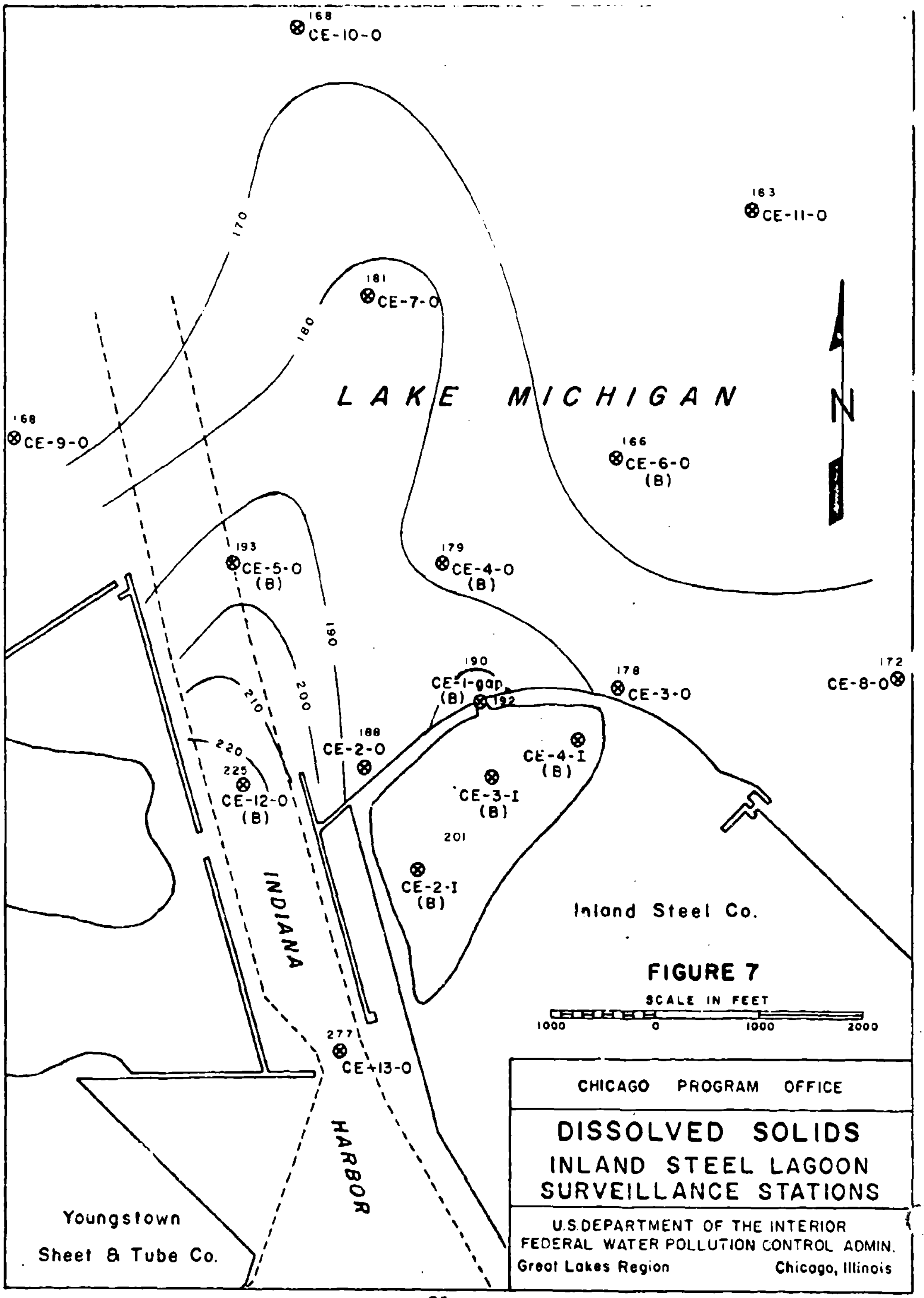
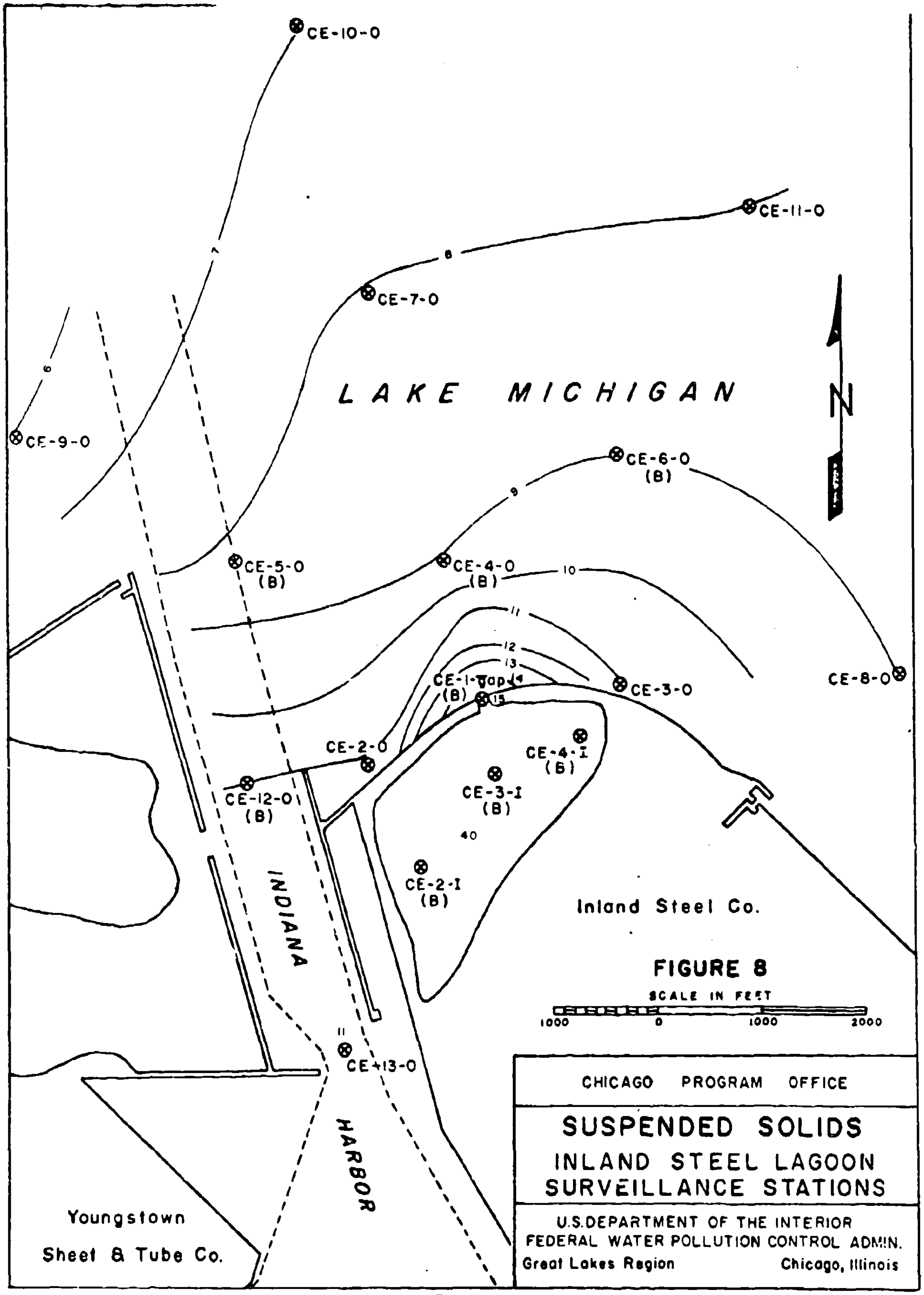

168
CE-10-0
163
CE-11-0
170
181
CE-7-0
180
LAKE MICHIGAN
N
168
CE-9-0
166
CE-6-0
(B)
193
CE-5-0
(B)
179
CE-4-0
(B)
190
200
210
190
CE-1-gap
(B)
192
178
CE-3-0
172
CE-8-0
220
188
CE-2-0
CE-4-I
(B)
225
CE-12-0
(B)
CE-3-I
(B)
201
INDIANA
CE-2-I
(B)
Inland Steel Co.
SCALE IN FEET
1000
0
1000
2000
277
CE-13-0
HARBOR
Youngstown
Sheet & Tube Co.
CHICAGO PROGRAM OFFICE
DISSOLVED SOLIDS
INLAND STEEL LAGOON
SURVEILLANCE STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois

FIGURE 7


CE-10-0
CE-11-0
CE-7-0
LAKE MICHIGAN
N
CE-9-0
CE-6-0 (B)
CE-5-0 (B)
CE-4-0 (B)
CE-1-Top (B)
CE-3-0
CE-8-0
CE-2-0
CE-12-0 (B)
CE-4-I (B)
CE-3-I (B)
CE-2-I (B)
INDIANA
HARBOR
Inland Steel Co.
CE-13-0
Youngstown
Sheet & Tube Co.
FIGURE 8
SCALE IN FEET
1000 0 1000 2000
CHICAGO PROGRAM OFFICE
SUSPENDED SOLIDS
INLAND STEEL LAGOON
SURVEILLANCE STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois

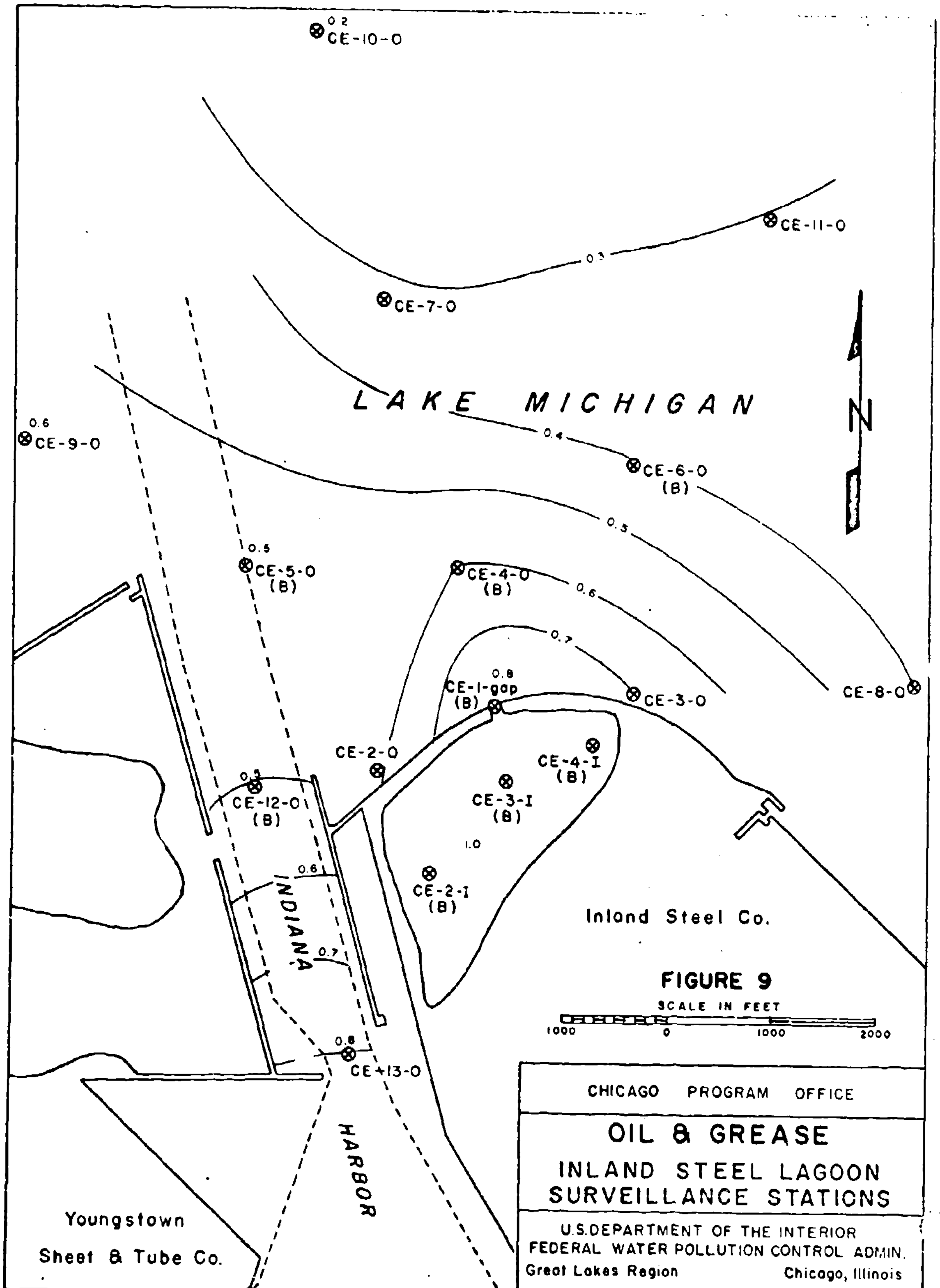


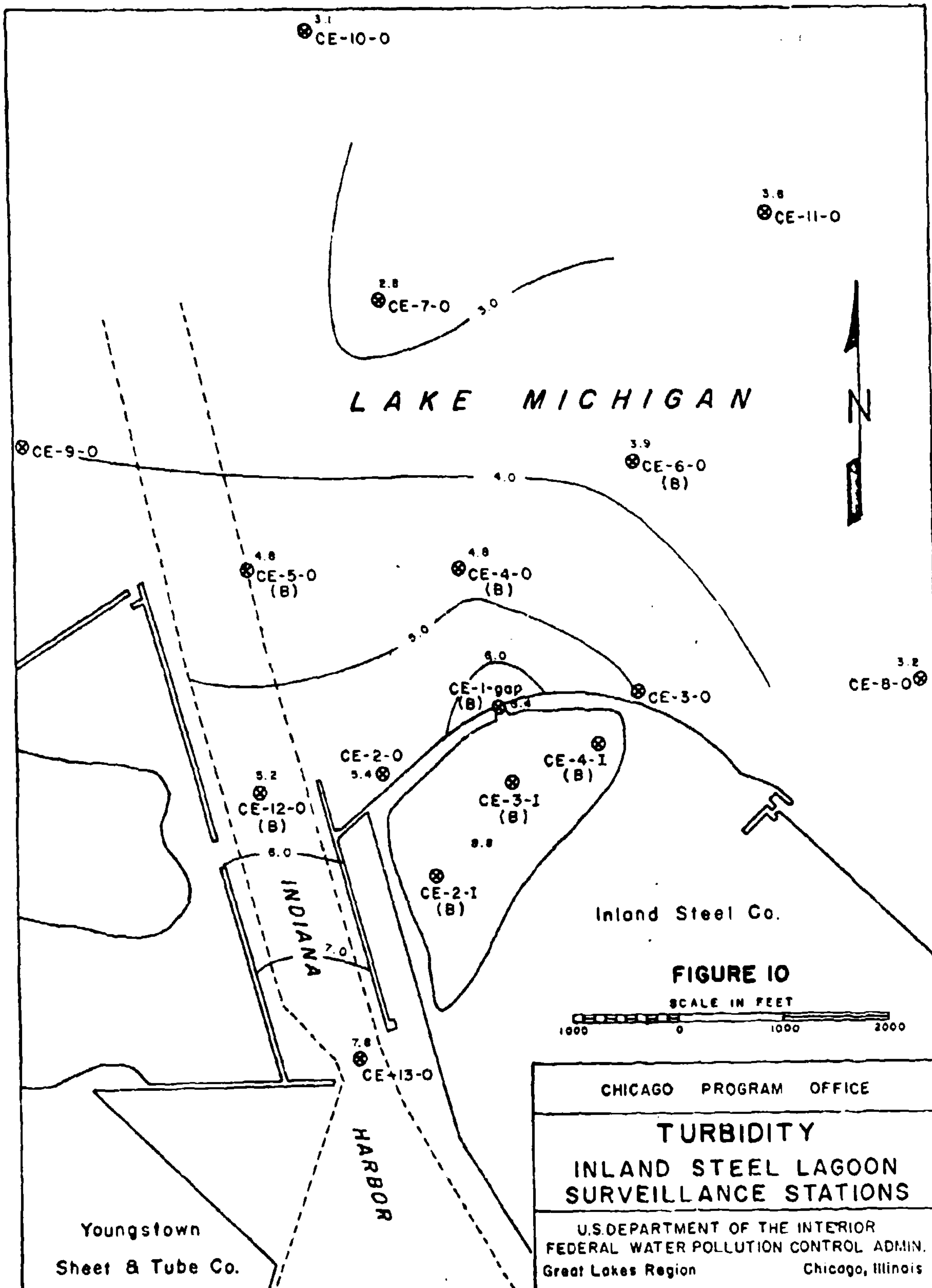
FIGURE 9

CHICAGO PROGRAM OFFICE

OIL & GREASE

INLAND STEEL LAGOON
SURVEILLANCE STATIONS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region Chicago, Illinois



3.1
CE-10-0
3.8
CE-11-0
2.8
CE-7-0
3.0
LAKE MICHIGAN
N
CE-9-0
3.9
CE-6-0
(B)
4.0
4.8
CE-5-0
(B)
4.8
CE-4-0
(B)
5.0
6.0
CE-1-gap
(B)
CE-3-0
3.2
CE-8-0
CE-2-0
5.4
CE-4-I
(B)
5.2
CE-12-0
(B)
CE-3-I
(B)
6.0
INDIANA
CE-2-I
(B)
Inland Steel Co.
7.0
7.8
CE-13-0
HARBOR
Youngstown
Sheet & Tube Co.
FIGURE 10
SCALE IN FEET
1000
0
1000
2000
CHICAGO PROGRAM OFFICE
TURBIDITY
INLAND STEEL LAGOON
SURVEILLANCE STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois

TABLE 3

INLAND STEEL LAGOON SURVEILLANCE

Stations 2I, 3I, 4I Inside Lagoon

Date	Temp. °C	pH	NO_2-NO_3-N - mg/1	NH_3-N mg/1	Org.N mg/1	Sol.P mg/1	Tot.P mg/1	COD mg/1	Dis. Solids mg/1	Susp. Solids mg/1	Oil & grease mg/1	Turb. units	Remarks
11/6/67 (2I)before*	7	9.1	0.26	1.4	0.30	0.010	0.022	7.2	194	23	NF		wind west water green
(2I)after*	7	8.4	0.27	0.78	0.27	0.014	0.180	11	200	194	NF		water purple
11/7/67 (2I)	7	8.4	0.16	1.4	0.16	0.021	0.060	8.9	214	25	NF		wind north
11/21/67 (3I)	6	8.3	0.10	0.99	0.10	0.014	0.057	38	172	18	0.3	8.4	wind south, heavy oil on surf--e, water murky grey
(4I)after*	6	9.0	0.22	1.1	0.22	0.024	0.101	46	193	30	2.3	5.6	heavy oil on surface, water black
11/28/67 (4I)	4	8.6	0.27	1.2	0.60	0.011	0.025	15	232	18	-	9.0	wind west
12/1/67 (3I)	4	8.6	0.27	1.3	0.27	0.023	0.106	14	218	21	NF	13.5	wind south, oil on surface
12/5/67 (4I)	4	8.9	0.22	0.95	0.75	0.022	0.077	12	190	13	NF	8.0	wind south, oil on surface, water murky
12/12/67 (3I)	5	8.6	0.28	1.4	0.63	0.032	0.105	8.4	193	21	5.0	8.4	wind west, oil on surface, water murky

*before - Sample collected before dumping started
after - Sample collected immediately after a barge was dumped

TABLE 4

INLAND STEEL LAGOON SURVEILLANCE

Station CE 1-0 gap

Date	Temp. ^oC	pH	NO_2-NO_3-N - mg/1	NH_3-N mg/1	Org.N mg/1	Sol.P mg/1	Tot.P mg/1	COD mg/1	Dis. Solids mg/1	Susp. Solids mg/1	Oil & grease mg/1	Turb. units	Remarks
11/6/67	7	8.7	0.15	0.46	0.30	0.014	0.071	2.5	190	13	NF		wind south, water green
11/7/67	8	7.9	0.17	0.97	0.43	0.018	0.046	1.3	215	28	0.1		wind north, water murky
11/21/67	6	7.7	0.23	0.53	0.40	0.015	0.042	27	171	10	0.3	3.2	wind south, oil on surface
11/29/67	4	7.2	0.25	0.40	0.26	0.017	0.036	12	187	20	0.4	5.9	wind S.E., oil on surface
12/1/67	3	8.4	0.68	0.49	0.47	0.020	0.039	9.0	190	11	1.6	9.0	wind south, oil on surface bubbler operating
12/5/67	4	8.7	0.21	0.55	0.34	0.021	0.070	13	189	14	0.8	7.0	wind south, oi on surface, bubbler in operation
12/12/67	3	8.4	0.29	1.0	0.90	0.023	0.060	6.8	199	9	2.4	6.6	wind west, oil on surface, bubbler not operating

TABLE 5

INLAND STEEL LAGOON SURVEILLANCE

Station CE 2-0

Date	Temp. °C	pH	NO_2-NO_3-N - mg/1	NH_3-N mg/1	Org.N mg/1	Sol.P mg/1	Tot.P mg/1	COD mg/1	Dis. Solids mg/1	Susp. Solids mg/1	Oil & grease mg/1	Turb. units	Remarks
11/6/67	8	7.7	0.22	0.33	0.41	0.018	0.036	5.1	177	15	NF		wind west, oil on surface
11/7/67	11	-	0.27	0.65	0.45	0.021	0.043	2.6	205	12	0.5		wind north
11/21/67	6	7.7	0.26	0.48	0.25	0.014	0.028	27	173	10	NF	2.0	wind south
11/29/67	4	8.2	0.25	0.46	0.34	0.009	0.024	12	195	12	0.6	7.7	wind southeast
12/1/67	3	8.1	0.66	0.35	0.49	0.018	0.036	14	190	9	0.5	6.2	wind south
12/5/67	4	8.3	0.20	0.40	0.38	0.016	0.035	12	175	8	0.4	7.4	wind south
12/12/67	7	7.9	0.35	0.86	0.44	0.021	0.046	3.9	200	9	1.9	3.9	wind west, water murky

TABLE 6

INLAND STEEL LAGOON SURVEILLANCE

Station CE 3-0

Date	Temp. °C	pH	NO_2-NO_3-N - mg/1	NH_3-N mg/1	Org.N mg/1	Sol.P mg/1	Tot.P mg/1	COD mg/1	Dis. Solids mg/1	Susp. Solids mg/1	Oil & grease mg/1	Turb. units	Remarks
11/6/67	7	7.8	0.12	0.20	0.37	0.015	0.032	2.1	168	25	NF		wind west, water murky
11/7/67	10	-	0.27	0.65	0.45	0.021	0.043	2.6	205	12	0.5		wind north
12/1/67	3	8.6	0.25	0.19	0.22	0.014	0.022	7.7	171	5	0.1	4.0	wind southeast
12/5/67	3	8.5	0.20	0.17	0.28	0.012	0.028	12	165	6	0.2	6.1	wind south
12/12/67	6	8.2	0.24	0.66	0.44	0.026	0.042	5.0	185	8	2.8	5.0	wind west

TABLE 7

INLAND STEEL LAGOON SURVEILLANCE

Station CE 4-0

Date	Temp. °C	pH	NO_2-NO_3-N - mg/1	NH_3-N mg/1	Org.N mg/1	Sol.P mg/1	Tot.P mg/1	COD mg/1	Dis. Solids mg/1	Susp. Solids mg/1	Oil & grease mg/1	Turb. units	Remarks
11/6/67	7	7.5	0.23	0.40	0.36	0.013	0.039	3.0	177	16	NF		wind west, oil on surface
11/7/67	10	-	0.22	0.68	0.31	0.020	0.045	3.8	111	10	0.9		wind north
11/21/67	7	8.1	0.26	0.69	0.41	0.017	0.041	23	184	10	NF	2.2	wind south - light, oil on surface
11/28/67	3	7.5	0.13	0.10	0.17	0.011	0.025	11	180	15	NF	7.0	wind west - strong, water rough
11/29/67	4	8.1	0.30	0.44	0.11	0.009	0.024	12	186	10	0.7	3.9	wind southeast
12/1/67	3	8.6	0.16	0.21	0.22	0.014	0.024	8.2	184	3	NF	5.0	wind south
12/5/67	6	8.0	0.24	0.78	0.52	0.020	0.053	12	217	3	0.7	4.5	wind south
12/12/67	6	8.2	0.24	0.63	0.24	0.025	0.039	6.1	191	8	2.8	6.1	wind west

TABLE 8

INLAND STEEL LAGOON SURVEILLANCE

Station CE 5-0

Date	Temp. °C	pH	NO_2-NO_3-N - mg/1	NH_3-N mg/1	Org.N mg/1	Sol.P mg/1	Tot.P mg/1	COD mg/1	Dis. Solids mg/1	Susp. Solids mg/1	Oil & grease mg/1	Turb. units	Remarks
11/7/67	10	-	0.19	0.59	0.32	0.022	0.039	2.5	214	12	0.9		wind north
11/21/67	7	8.1	0.24	0.35	0.29	0.017	0.052	23	190	15	NF	2.4	wind south, grease blobs
11/29/67	5	8.3	0.27	0.50	0.21	0.011	0.027	10	183	6	NF	3.9	wind southeast
12/1/67	6	7.6	0.16	0.21	0.22	0.014	0.024	8.2	184	3	NF	5.0	wind south, water brown
12/5/67	7	7.8	0.26	0.82	0.48	0.021	0.053	7.3	21[illegible]	6	NF	7.0	wind south, water murky
12/12/67	5	8.1	0.23	0.45	0.11	0.026	0.039	5.9	175	8	2.0	5.9	wind west

TABLE 9

INLAND STEEL LAGOON SURVEILLANCE

Station CE 6-0

Date	Temp. °C	pH	NO_2-NO_3-N - mg/1	NH_3-N mg/1	Org.N mg/1	Sol.P mg/1	Tot.P mg/1	COD mg/1	Dis. Solids mg/1	Susp. Solids mg/1	Oil & grease mg/1	Turb. units	Remarks
11/7/67	9	-	0.19	0.55	0.25	0.023	0.039	1.7	195	13	0.3		wind north
11/21/67	4	8.4	0.11	0.06	0.23	0.011	0.024	15	150	10	NF	1.5	wind south
11/29/67	3	8.5	0.13	0.01	0.08	0.007	0.013	12	164	10	NF	3.9	wind southeast
12/1/67	3	8.3	0.17	0.18	0.18	0.013	0.015	47	171	3	NF	2.4	wind south
12/5/67	3	8.6	0.15	0.18	0.12	0.009	0.021	13	159	9	0.8	5.9	wind south
12/12/67	3	8.2	0.14	0.12	0.55	0.016	0.025	5.6	154	6	1.1	5.6	wind west

TABLE 10

INLAND STEEL LAGOON SURVEILLANCE

Station CE 7-0

Date	Temp. °C	pH	NO_2-NO_3-N - mg/1	NH_3-N mg/1	Org.N mg/1	Sol.P mg/1	Tot.P mg/1	COD mg/1	Dis. Solids mg/1	Susp. Solids mg/1	Oil & grease mg/1	Turb. units	Remarks
11/7/67	7	-	0.13	0.16	0.18	0.016	0.024	0.4	175	10	0.1		wind north
11/21/67	6	8.0	0.30	0.52	0.34	0.017	0.057	15	167	11	NF	2.2	wind south
11/29/67	6	8.1	0.34	0.61	0.23	0.009	0.025	10	205	10	NF	1.5	wind southeast
12/1/67	3	8.3	0.28	0.22	0.17	0.013	0.018	7.3	183	3	NF	2.5	wind south
12/5/67	5	8.1	0.21	0.66	0.44	0.019	0.046	16	198	8	0.3	4.5	wind south
12/12/67	4	8.4	0.15	0.15	0.17	0.011	0.018	3.2	156	6	1.1	3.2	wind west

TABLE 11

INLAND STEEL LAGOON SURVEILLANCE

Station CE 8-0

Date	Temp. °C	pH	NO_2-NO_3-N - mg/1	NH_3-N mg/1	Org.N mg/1	Sol.P mg/1	Tot.P mg/1	COD mg/1	Dis. Solids mg/1	Susp. Solids mg/1	Oil & grease mg/1	Turb. units	Remarks
11/7/67	10	-	0.16	0.62	0.18	0.021	0.043	5.1	196	10	0.3		wind north
11/21/67	4	7.5	0.13	0.06	0.21	0.010	0.027	15	155	6	NF	1.7	wind south
11/29/67	3	7.4	0.12	0.04	0.09	0.010	0.017	9.4	164	12	NF	3.9	wind southeast
12/1/67	3	8.5	0.13	0.11	0.14	0.013	0.015	7.7	163	4	0.9	3.7	wind south
12/5/67	3	8.7	0.54	0.15	0.26	0.012	0.025	15	156	9	0.3	3.0	wind south
12/12/67	5	8.2	0.20	0.47	0.21	0.028	0.028	3.9	200	11	0.6	3.9	wind west

TABLE 12

INLAND STEEL LAGOON SURVEILLANCE

Station CE 9-0

Date	Temp. °C	pH	NO_2-NO_3-N - mg/l	NH_3-N mg/l	Org.N mg/l	Sol.P mg/l	Tot.P mg/l	COD mg/l	Dis. Solids mg/l	Susp. Solids mg/l	Oil & grease mg/l	Turb. units	Remarks
11/7/67	9	-	0.10	0.24	0.14	0.016	0.027	5.1	170	12	1.2		wind north
11/21/67	5	8.3	0.17	0.24	0.11	0.013	0.031	50	162	10	NF	1.7	wind south
11/29/67	2	7.8	0.15	0.03	0.06	0.006	0.017	12	161	10	NF	3.7	wind southeast
12/1/67	3	7.8	0.10	0.21	0.20	0.014	0.022	8.2	170	9	NF	6.5	wind south
12/5/67	4	7.9	0.19	0.30	0.50	0.012	0.032	13	168	8	0.6	3.7	wind south
12/12/67	3	8.2	0.19	0.15	0.47	0.018	0.025	4.5	178	14	1.9	4.5	wind west

TABLE 13

INLAND STEEL LAGOON SURVEILLANCE

Station CE 10-0

Date	Temp. °C	pH	NO_2-NO_3-N - mg/1	NH_3-N mg/1	Org.N mg/1	Sol.P mg/1	Tot.P mg/1	COD mg/1	Dis. Solids mg/1	Susp. Solids mg/1	Oil & grease mg/1	Turb. units	Remarks
11/7/67	7	-	0.09	0.05	0.45	0.011	0.011	1.7	170	6	0.3		wind north
11/21/67	5	8.2	0.17	0.23	0.28	0.008	0.027	27	156	9	NF	2.0	wind south
11/29/67	3	8.3	0.12	0.01	0.06	0.006	0.011	12	168	9	NF	1.3	wind southeast
12/1/67	3	8.3	0.15	0.19	0.15	0.012	0.017	6.9	178	3	NF	3.1	wind south
12/5/67	5	8.1	0.19	0.45	0.56	0.016	0.039	8.6	174	9	0.1	4.5	wind south
12/12/67	3	8.5	0.16	0.24	0.32	0.014	0.021	4.5	164	6	0.7	4.5	wind west, popcorn slag

TABLE 14

INLAND STEEL LAGOON SURVEILLANCE

Station CE 11-0

Date	Temp. °C	pH	NO_2-NO_3-N - mg/1	NH_3-N mg/1	Org.N mg/1	Sol.P mg/1	Tot.P mg/1	COD mg/1	Dis. Solids mg/1	Susp. Solids mg/1	Oil & grease mg/1	Turb. units	Remarks
11/7/67	9	-	0.17	0.40	0.19	0.020	0.031	4.7	176	9	NF		wind north
11/21/67	4	8.0	0.09	0.02	0.16	0.008	0.028	46	147	8	0.3	1.5	wind south
11/29/67	3	8.6	0.10	0.01	0.03	0.008	0.010	11	165	9	0.7	2.2	wind southeast
12/1/67	3	8.5	0.10	0.02	0.25	0.008	0.017	6.9	169	2	0.3	3.1	wind south
12/5/67	3	8.6	0.16	0.10	0.15	0.012	0.025	7.3	161	10	0.5	7.0	wind south
12/12/67	3	8.6	0.11	0.07	0.31	0.016	0.021	8.0	158	28	NF	8.0	wind west

TABLE 15

INLAND STEEL LAGOON SURVEILLANCE

Station CE 12-0

Date	Temp. °C	pH	NO_2-NO_3-N - mg/l	NH_3-N mg/l	Org.N mg/l	Sol.P mg/l	Tot.P mg/l	COD mg/l	Dis. Solids mg/l	Susp. Solids mg/l	Oil & grease mg/l	Turb. units	Remarks
11/6/67	10	7.1	-	-	-	0.025	0.067	3.8	224	20	0.1		wind west, oil on surface
11/7/67	11	-	0.30	0.85	0.35	0.022	0.052	5.5	212	10	0.2		wind north
								38	205	14	0.2	2.0	wind west
11/21/67	8	7.3	0.30	0.70	0.43	0.017	0.080						
11/29/67	8	7.5	0.50	1.3	0.50	0.018	0.043	12	238	10	0.9	3.5	wind southeast, oil on surface
12/1/67	8	7.8	0.30	1.3	0.47	0.018	0.064	11	220	7	1.0	4.5	wind south, oil on surface, water brown
12/5/67	9	7.6	0.32	1.3	0.50	0.025	0.070	16	278	10	0.4	9.4	wind south, water murky
12/12/67	9	7.9	0.35	1.5	0.40	0.019	0.067	6.8	197	5	0.6	6.8	wind south, water murky

TABLE 16

INLAND STEEL LAGOON SURVEILLANCE

Station CE 13-0

Date	Temp. ^{o}C	pH	NO_2-NO_3-N - mg/1	NH_3-N mg/1	Org.N mg/1	Sol.P mg/1	Tot.P mg/1	COD mg/1	Dis. Solids mg/1	Susp. Solids mg/1	Oil & grease mg/1	Turb. units	Remarks
11/7/67	10	-	0.27	0.89	0.31	0.017	0.053	7.6	219	16	0.7		wind north, oil on surface
11/21/67	11	7.0	0.39	1.47	0.40	0.019	0.091	31	215	13	0.3	3.7	wind west
11/28/67	10	7.4	-	-	-	0.014	0.060	-	276	10	NF	9.0	wind west
11/29/67	11	7.0	0.61	1.4	0.60	0.032	0.067	9.0	261	14	1.1	10.1	wind southeast, oil on surface
12/1/67	11	7.5	0.43	1.9	0.20	0.025	0.043	13	263	7	1.8	9.0	wind south, oil on surface, water brown
12/5/67	10	7.5	0.38	1.5	0.50	0.030	0.102	15	245	10	1.6	8.4	wind south, oil on surface water murky
12/12/67	12	7.7	0.41	1.8	0.80	0.023	0.095	6.8	152	6	0.2	6.8	wind west oil on surface water murky

APPENDIX A

ANALYSIS OF BOTTOM SAMPLES 12/12/67

All results in mg/kg - Dry Basis

Parameter	CE 1-gap + 50 50 yds outside gap	CE 3-I Inside lagoon	CE 12-0 Indiana Harbor
% Total Solids	78.9%	35.1%	37.9%
% Tot. Vol.Solids	3.3%	8.0%	6.6%
COD	5210	351,500	261,500
NH_3-N	NF	327	264
NO_3-N	2.7	3.1	22
Org N	28	1945	757
Total Phosphorus	107	986	786
Tot. Sol. Phosphorus	1.18	6.74	1.32
Phenol	0.04	1.14	0.97
Oil & Grease	425	39,500	27,900
Total Iron	21,450	17,210	57,000
Cyanide	NF	4.33	5.70
Sulphide	5.8	986	351
Copper	28.5	45.6	95.5
Cadmium	NF	NF	NF
Nickel	19.0	NF	NF
Zinc	841	747	1480
Lead	279	314	396
Chromium	63.4	94.0	79.2

APPENDIX A8

CALUMET RIVER

DREDGING PILOT PROJECT

1967 - 1968

U. S. Department of the Interior

Federal Water Pollution Control Administration
Great Lakes Region
Chicago, Illinois

TABLE OF CONTENTS

Introduction

With responsibility for maintenance of the waterways of the United States delegated to the United States Army Corps of Engineers, and with the FWPCA being interested in the effects of dredging and dumping operations on water quality, a joint agreement included provisions for studies to develop alternate disposal methods. In conjunction with a pilot program to develop such alternate means of disposal, a land disposal site was located in the vicinity of Lake Calumet to accommodate the dredged material from the new work and maintenance dredging project in the Calumet River between Lake Michigan and Turning Basin No. 5 (see Figure 1).

The 91-acre-land disposal area is located east of Lake Calumet and north of the Calumet River in Chicago, Illinois. Dredged material is transported by scows from the dredging location to a temporary disposal site in Slip No. 2. The material is then pumped by a hydraulic dredge from the temporary spoil area by a 16 inch pipeline to the land site. Effluent from the land area subsequently drains by a ditch southward to an outfall on the Calumet River (see Figure 2).

A sampling program was established for the purpose of evaluating the dredging and disposal methods in use at this Calumet River Pilot Project. The procedure for surveillance of this project involves sampling above and below the dredging location, sediment sampling from the scow, water sampling in the vicinity of the temporary spoil area and collection of water samples from the land disposal outlet. Determination of the effectiveness of this disposal method is based upon an evaluation of the results obtained from the sampling program, and on observation of the dredging procedure.

Conclusions

1. Dredging operations had a negligible immediate effect on water quality of the Calumet River.
2. There was no pronounced difference in water quality at the temporary spoil area inside or outside the submerged dike before or after dumping.
3. The dredged material dumped into the temporary spoil area was reasonably contained.
4. The detention time for settlement was not long enough to effectively reduce the turbidity and suspended solids to a degree which could be realized if control of the drainage was improved.
5. With exception of nitrate nitrogen and total soluble phosphorus, all parameters were higher at the land spoil outlet than at any other location sampled.
6. Bottom sediment samples indicate that pollutional material is present in high concentrations in Calumet River.

Chronology

April 14, 1967 - FWPCA was informed by the Corps of Engineers that it tentatively planned to dispose of dredged material in a land spoil area in the vicinity of Lake Calumet.

July 12, 1967 - Predredging bottom sediment samples collected

September 1, 1967 - The contractor commenced maintenance dredging. All material to be dredged was to be deposited in a temporary disposal area in Slip No. 2 in Lake Calumet. The contractor proposes to accumulate dredged material in a temporary spoil area until October 1-15, 1967 at which time a hydraulic dredge will be placed in operation to rehandle the material from Slip No. 2 to the land disposal area.

October 3, 1967 - Rehandling of dredged material from temporary spoil area to land disposal area started.

October 26, 1967 - On site inspection of land disposal area performed by FWPCA personnel. Water samples collected at drainage ditch outlet to the Calumet River.

November 9, 1967 - Initial collection of water and sediment samples taken at three locations:

(1) vicinity of dredge - water samples 1000 feet upstream and downstream from dredge and sediment samples from scow

(2) temporary spoil area - inside and outside submerged dike

(3) outfall ditch from land spoil area to outlet.

Chronology (continued)

November 16, 1967 - Collection of water and sediment samples.

November 22, 1967 - Collection of water and sediment samples.

November 30, 1967 - Water samples taken at all stations; included samples collected one-half hour before and after dumping at temporary spoil area.

December 6, 1967 - Dredging operations terminated.

January 12, 1968 - Collection of water samples at land spoil outfall.

January 17, 1968 - Collection of water samples at land spoil outfall.

February 5, 1968 - Pumping of dredged material from temporary spoil area to land spoil area completed.

DISCUSSION OF ANALYSIS

Bottom Sediments

Predredging bottom sediment samples were collected in Calumet River on July 12, 1967 with the results shown on Table 1. Sediment samples during the 1967 - 1968 dredging period consisted of a series of three weekly samples collected directly from the bottom-dump scow into which the dredged material was placed by means of a clam-shell type bucket dredge. Representative samples were obtained from at least 5 hoppers on the scow and composited. The results of the analyses performed on the composite are presented in Table 2.

The laboratory results of the samples taken prior to dredging indicate pollutional material present in the bottom sludge. COD, ammonia, phosphates, oil and grease, iron and the toxic metals, namely copper, lead, chromium, zinc and nickel are present in high concentrations.

The iron and toxic metals are indicative of iron and steel and other industrial waste discharges.

Water Quality

Water samples were collected in the project area during the dredging operations on seven different occasions. The results of the four samples taken 1000 feet above and below the dredge on the Calumet River reveal no significant differences in water quality due to dredging activity although downstream from the dredge there was a slight increase in suspended and dissolved solids and turbidity. The analyses for the water samples in the vicinity of the dredge is shown in Table 4.

Samples were collected both inside and outside of the submerged dike at the temporary spoil area and on one occasion samples were taken one-half hour before and after dumping into the area. The data in Table 5 indicates that inside the diked area, the turbidity and suspended solids are higher one-half hour after dumping compared with samples taken before dumping. However, outside the submerged dike the turbidity and suspended solids are no higher before or after dumping which demonstrates that the dike was generally effective in containing the dredged material inside the temporary spoil area.

The Corps of Engineers, through soundings of the temporary spoil area before and after dumping concluded that for all practical purposes the entire volume of approximately 277,000 cubic yards was pumped onto the land spoil area.

Water samples were collected at the land spoil outlet on seven occasions to determine the quality of water draining from this land area back to the Calumet River. A comparison of average values in Table 3 shows that concentrations of organic nitrogen, total phosphorus, COD, solids, oil and grease and turbidity were much higher in the effluent from the disposal area than in any of the other waters sampled.

It should be noted that individual test results on the effluent samples varied widely (see Table 6). These results may be affected by the type and quantity of material being deposited in the spoil area on the days sampled, by the mixing which occurs in the hydraulic dredging operation, and by rainfall which has occurred immediately prior to sampling.

On October 26, 1967, three weeks after pumping to the land spoil area was begun, an on-site inspection of the area was made. The appearance of the water drained in the outlet ditch was obviously higher in solids than the receiving waters of the Calumet River and oil was visible on the surface in the outlet ditch. The physical character of the disposal area did not provide adequate time for settlement. The condition at the outlet of the hydraulic pipeline did show results of solid material building up, but from this point the water containing large amounts of suspended solids flowed overland across a wide area, into the drainage ditch and was discharged through the outlet culvert to the Calumet River.

Additional settling time is necessary to reduce suspended solids before discharge to the Calumet River. The disposal area should be diked with a controlled outlet to regulate the overflow after a longer settling time has been realized.

Graphical presentations of the water quality data are shown in Figures 3 - 12.

TABLE 1

CALUMET RIVER - BOTTOM SEDIMENTS

Results expressed in mg/kg - dry basis

July 12, 1967

Station	1	2	6	7	9	10	11
River Mile	332.8	332.2	331.2	330.7	330.2	329.1	327.7
Parameter							
% Total Solids	49.4	58.3	59.0	45.5	58.2	50.3	57.9
% Volatile Solids	4.4	6.2	6.4	13.2	9.4	9.0	5.7
NH_3-N	59	76	98	148	65	81	66
NO_3-N	9.4	1.7	0.7	0.7	1.2	0.6	0.3
Organic-N	741	964	1192	902	685	1199	1134
Total Soluble Phosphorus	2.31	4.10	11.5	8.68	2.13	1.65	2.33
Total Phosphorus	1370	1161	2031	686	447	2175	539
Oil and Grease	4900	5900	8080	20,850	26,100	34,400	3420
COD	87,200	95,200	132,000	197,000	231,500	165,000	69,900
Phenol	1.865	1.800	0.305	1.710	1.080	1.070	0.260
Cyanide	2.94	1.72	9.50	33.6	12.2	9.85	0.014
Sulfide	619	292	242	600	394	585	78
Total Iron	88,700	70,100	50,600	96,100	75,400	80,600	27,550
Cu	*	9.8	7.6	22	12	25	14
Cd	*	*	*	*	*	*	*
Ni	12	*	*	23	*	32	*
Zn	39	59	149	472	330	410	127
Pb	79	129	168	440	820	626	103
Cr	8.1	8.6	12	20	62	68	19

* Not detected at sensitivity of test

Table 2

CALUMET RIVER DREDGING STUDY

Sediment Samples

All results in mg/kg - Dry Basis

Parameter	Barge Hopper November 22, 1967
% Total Solids	76.1 %
% Total Vol. Solids	9.8 %
COD	25,150
NH_3- N	69.3
NO_3- N	2.1
Organic - N	750
Total Sol. -P	0.752
Total - P	289
Phenol	0.18
Oil & Grease	1,000
Copper	9.20
Cadmium	NF
Nickel	25.0
Zinc	47.5
Lead	123
Chromium	13.1
Total Iron	17,890
Cyanide	NF
Sulfide	6.0

N.F. - None Found

TABLE 3

CALUMET RIVER DREDGING STUDY

All Stations - Average Values
Water Samples

Sampling Location	Org-N (mg/1)	NH_3-N (mg/1)	NO_3-N (mg/1)	Total Sol.-P (mg/1)	Tot.-P (mg/1)	COD (mg/1)	Dis. Solids (mg/1)	Sus. Solids (mg/1)	Oil & Grease (mg/1)	Tu (u
Above dredge	0.86	2.5	0.92	0.031	0.107	12	304	42	1.4	20
Below dredge	0.55	2.4	1.05	0.024	0.148	14	342	62	0.5	39
Outside Dike (before dumping)	0.67	2.5	1.2	0.019	0.070	14	398	45	0.9	23
Outside Dike (after dumping)	1.13	2.3	1.1	0.013	0.043	13	378	53	0.3	39
Inside Dike (before dumning)	0.50	2.4	1.4	0.018	0.079	14	392	53	0.3	33
Inside Dike (after dumping)	0.65	2.4	1.2	0.010	0.086	22	402	180	N.F.	90
Land Spoil Outlet	10.0	5.4	1.0	0.018	4.676	1250	520	10,830	14.4	11,300

N.F. -- None found

Table 4

Calumet River, Illinois

LAND DISPOSAL PILOT PROJECT SURVEILLANCE

Water Sampling Analysis

Location: Calumet River, 1000 ' above or below dredge

Date	Org-N (mg/l)	NH_3-N (mg/l)	NO_3-N (mg/l)	Total Sol.-P (mg/l)	Tot.-P (mg/l)	COD (mg/l)	Dis. Solids (mg/l)	Sus. Solids (mg/l)	Oil & Grease (mg/l)	Turbidity (units)
Nov. 9, 1967										
Above dredge	0.91	2.3	0.85	0.034	0.123	12	352	43	1.0	
Below dredge	0.10	2.2	0.90	0.025	0.186	14	342	76	0.5	
Nov. 22, 1967										
Above dredge	0.80	2.7	1.0	0.028	0.090	11	264	40	1.7	20
Below dredge	1.0	2.5	1.2	0.023	0.110	14	342	47	0.4	39

Table 5

Calumet River, Illinois

LAND DISPOSAL PILOT PROJECT SURVEILLANCE

Water Sampling Analysis

Location: Temporary Spoil Area at Submerged Dike

Date	Org-N (mg/l)	NH_3-N (mg/l)	NO_3-N (mg/l)	Total Sol.-P (mg/l)	Tot.-P (mg/l)	COD (mg/l)	Dis. Solids (mg/l)	Sus. Solids (mg/l)	Oil & Grease (mg/l)	Turbidity (units)
Nov. 9,1967										
Outside	0.80	2.0	1.1	0.027	0.116	11	366	37	0.8	
Inside	0.20	1.9	1.1	0.026	0.130	13	350	50	0.7	
Nov. 22,1967										
Outside	0.70	3.2	1.2	0.021	0.074	12	364	32	0.9	16
Inside	0.88	2.7	2.0	0.020	0.095	17	360	54	0.8	27
Nov. 30, 1967	(L)	or (R)	denotes left or right end of dike							
(L) Outside	0.40	2.6	1.3	0.016	0.088	15	403	45	0.3	26
(L) Inside	0.50	2.7	1.4	0.018	0.088	13	421	49	NF	32
(R) Outside	0.70	2.5	1.4	0.020	0.074	12	403	39	1.6	20
(R) Inside	0.20	2.5	1.4	0.016	0.016	13	398	52	NF	32
NF =	None Found									

Table 5 (continued)

Calumet River, Illinois

LAND DISPOSAL PILOT PROJECT SURVEILLANCE

Water Sampling Analysis

Location: Temporary Spoil Area at Submerged Dike

Date	Org-N (mg/l)	NH_3-N (mg/l)	NO_3-N (mg/l)	Total Sol.-P (mg/l)	Tot.-P (mg/l)	COD (mg/l)	Dis. Solids (mg/l)	Sus. Solids (mg/l)	Oil & Grease (mg/l)	Turbidity (units)
11/16/67	Following samples collected one-half hour before (B) and one-half hour after (A) dumping into the temporary sump area. (L) and (R) denote left and right of submerged dike location.									
Outside submerged dike:										
(L) (B)	0.20	2.3	1.1	0.015	0.026	14	469	63	1.5	34
(L) (A)	0.95	2.3	1.1	0.013	0.048	13	373	49	0.2	34
(R) (B)	1.2	2.4	1.1	0.013	0.045	12	376	56	None	40
(R) (A)	1.3	2.3	1.1	0.012	0.038	12	383	57	0.4	43
Inside submerged dike:										
(L) (B)	0.83	2.5	1.2	0.012	0.013	16	415	60	0.1	44
(L) (A)	0.50	2.3	1.3	0.011	0.126	25	414	175	None	88
(R) (B)	0.40	2.3	1.3	0.013	0.052	14	406	54	0.1	30
(R) (A)	0.8	2.4	1.1	0.008	0.045	19	389	185	None	91

Table 6

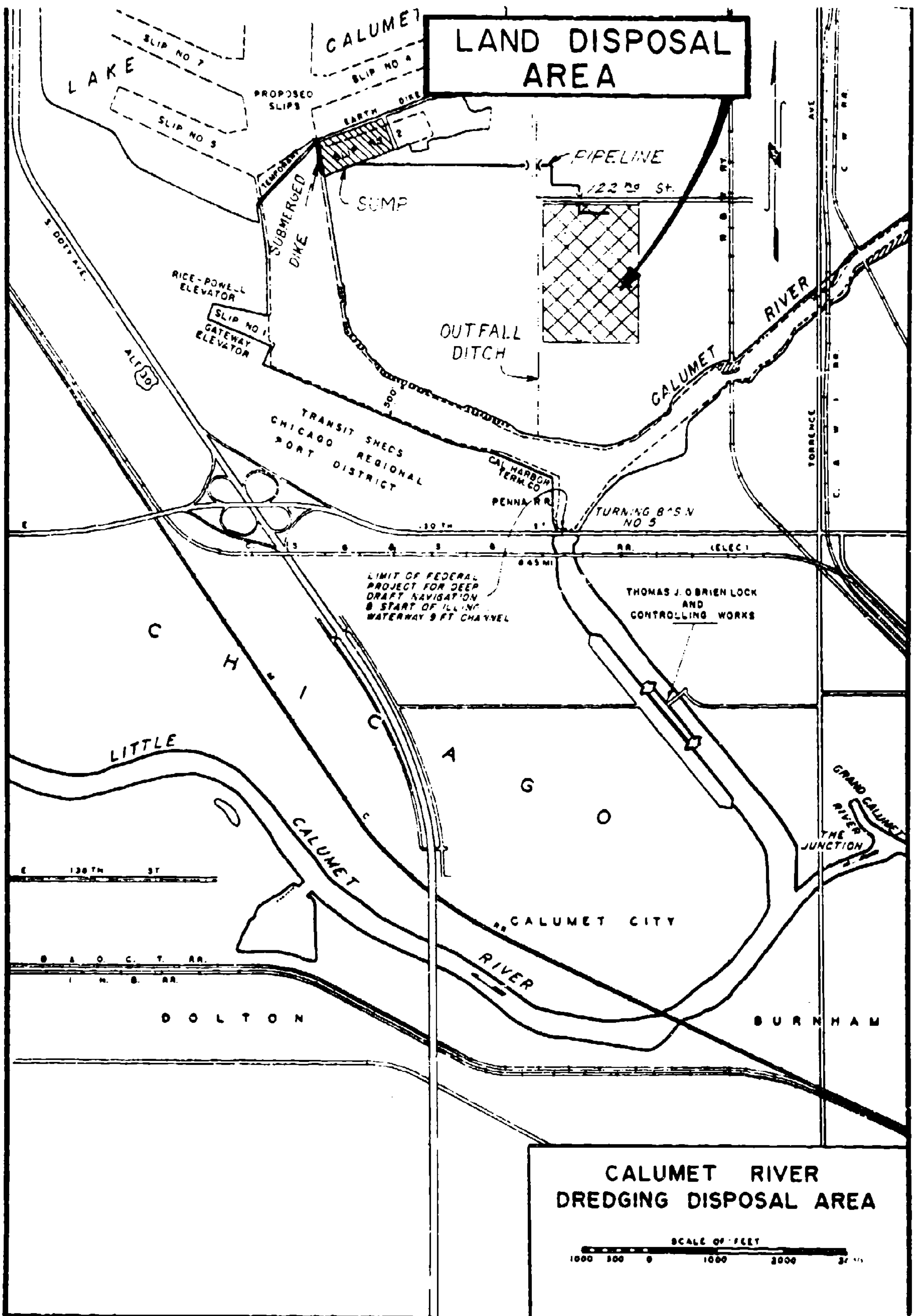
Calumet River, Illinois

LAND DISPOSAL PILOT PROJECT SURVEILLANCE

Water Sampling Analysis

Location: Land Spoil Outlet

Date	Org-N (mg/l)	NH_3-N (mg/l)	NO_3-N (mg/l)	Total Sol.-P (mg/l)	Tot.-P (mg/l)	COD (mg/l)	Dis. Solids (mg/l)	Sus. Solids (mg/l)	Oil & Grease (mg/l)	Turbidity (units)
10/26/67	2.0	5.7	1.2	0.018	0.560	90	358	1322	broken	
11/ 9/67	16	11	0.75	0.018	10.8	1115	500	12150	11	
11/16/67	4.1	4.9	0.75	0.022	0.321	2277	390	21830	4.8	20500
11/22/67	6.0	3.2	0.90	0.013	2.11	365	370	4140	7.4	4400
11/30/67	25	3.9	1.0	0.011	8.07	2594	526	15730	56	10000
1/12/68	9.8	4.2	1.3	0.025	4.07	773	701	8609	5.5	
1/17/68	7.9	5.1	1.1	0.021	6.80	1509	797	12203	1.5	



LAND DISPOSAL AREA
LAKE CALUMET
SLIP NO 7
SLIP NO 6
SLIP NO 5
PROPOSED SLIPS
EARTH DIKE
TEMPORARY
SUBMERGED DIKE
PIPELINE
SUMP
122ND ST.
RICE-POWELL ELEVATOR
SLIP NO 1
GATEWAY ELEVATOR
OUTFALL DITCH
CALUMET RIVER
TRANSIT SHEDS CHICAGO REGIONAL PORT DISTRICT
CAL HARBOR TERM. CO
PENNA RR
TURNING BASIN NO 5
LIMIT OF FEDERAL PROJECT FOR DEEP DRAFT NAVIGATION & START OF ILLINOIS WATERWAY 9 FT CHANNEL
THOMAS J. O'BRIEN LOCK AND CONTROLLING WORKS
TORRENCE AVE
CHICAGO
LITTLE CALUMET RIVER
CALUMET CITY
GRAND CALUMET RIVER
THE JUNCTION
DOLTON
BURNHAM
B. & O. C. T. RR.
I. H. B. RR.
CALUMET RIVER DREDGING DISPOSAL AREA
SCALE OF FEET
1000 500 0 1000 2000

Figure 1

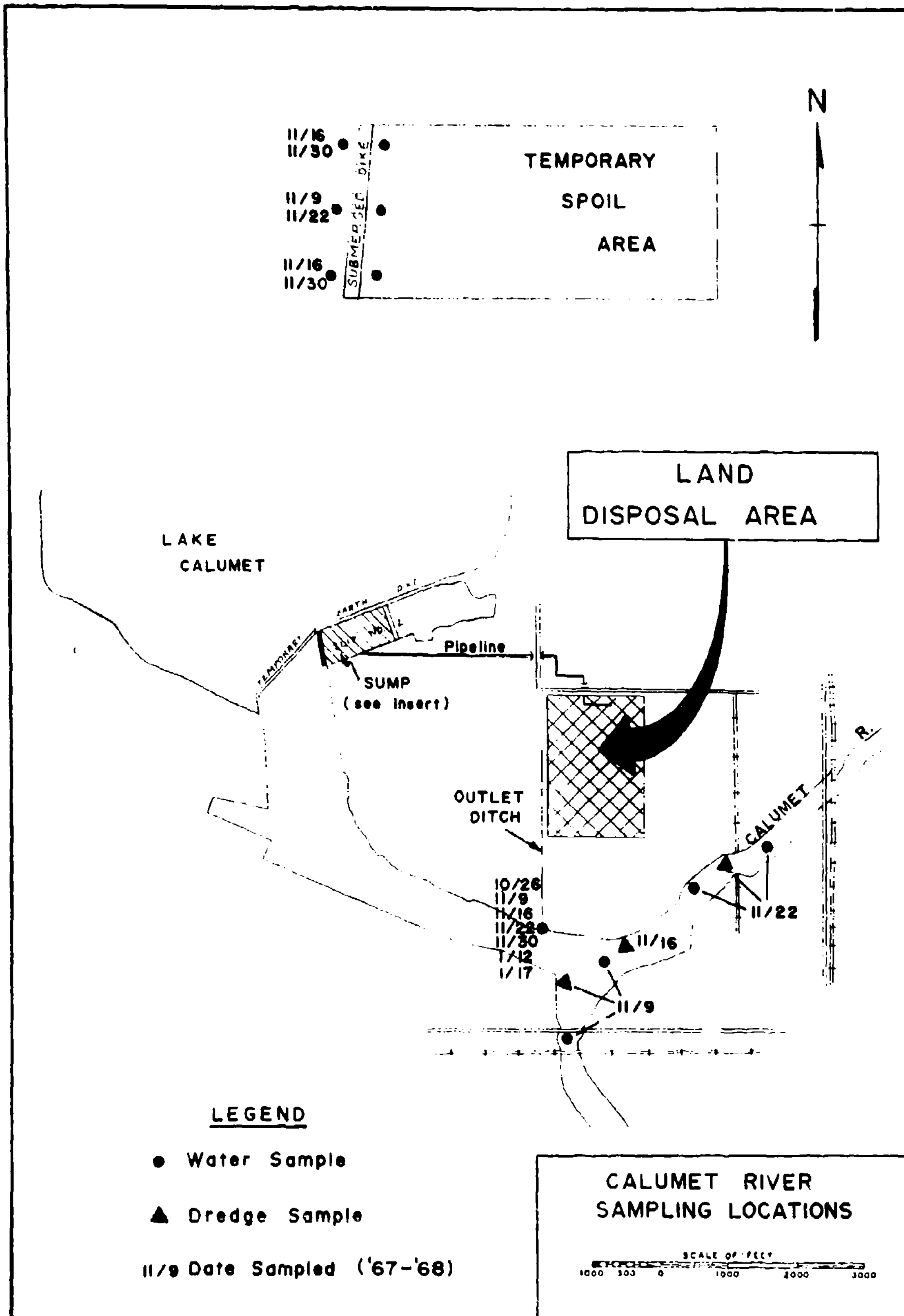

N
11/16
11/30
11/9
11/22
11/16
11/30
SUBMERGED DIKE
TEMPORARY
SPOIL
AREA
LAND
DISPOSAL AREA
LAKE
CALUMET
Pipeline
SUMP
(see insert)
OUTLET
DITCH
CALUMET R.
10/26
11/9
11/16
11/22
11/30
1/12
1/17
11/22
11/16
11/9
LEGEND
Water Sample
Dredge Sample
11/9 Date Sampled ('67–'68)
CALUMET RIVER
SAMPLING LOCATIONS

Figure 2

CALUMET RIVER DREDGING STUDY - Water Sample Analysis, 1967-68

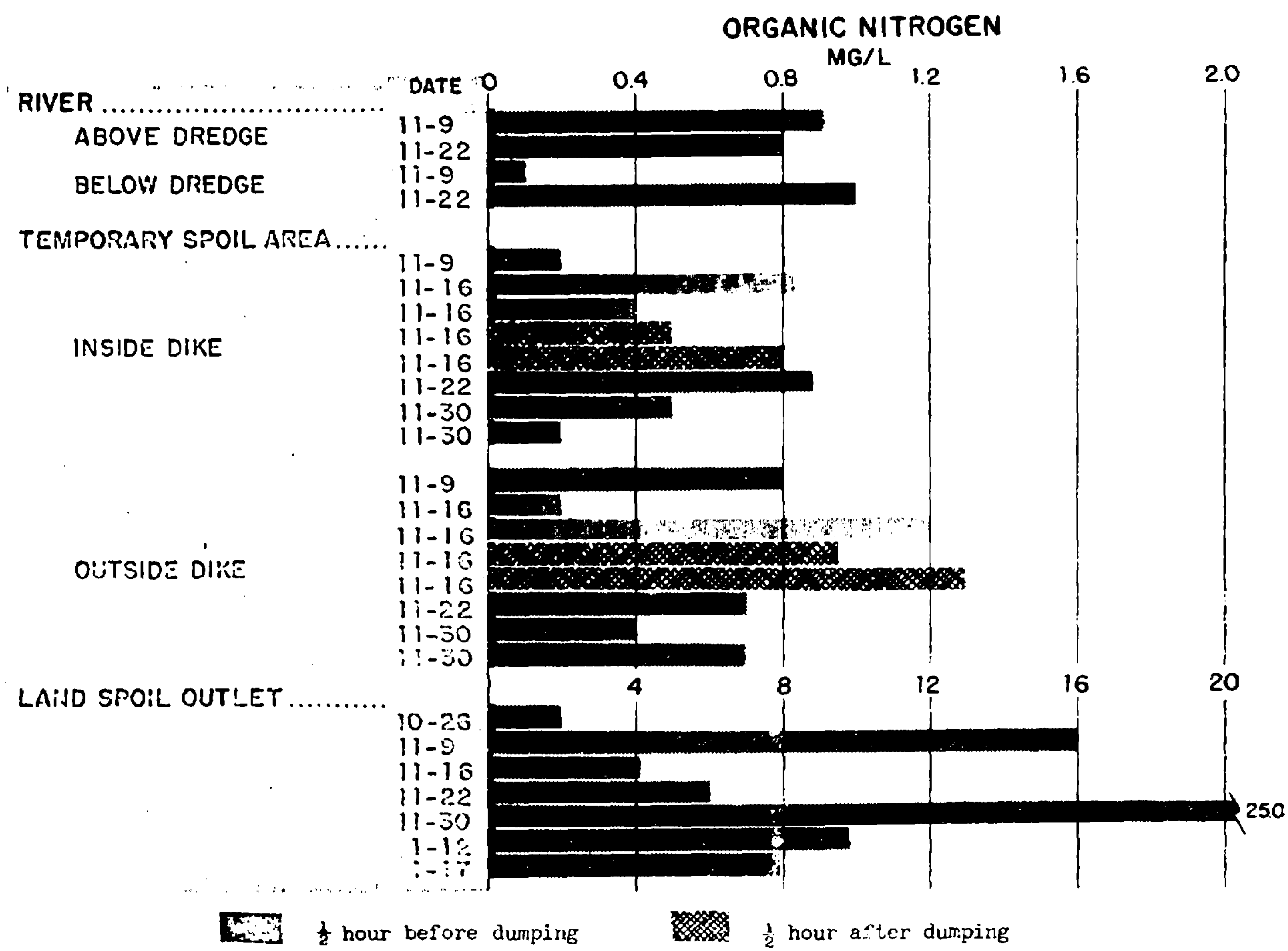


Figure 3

CALUMET RIVER DREDGING STUDY - Water Sample Analysis, 1967-68

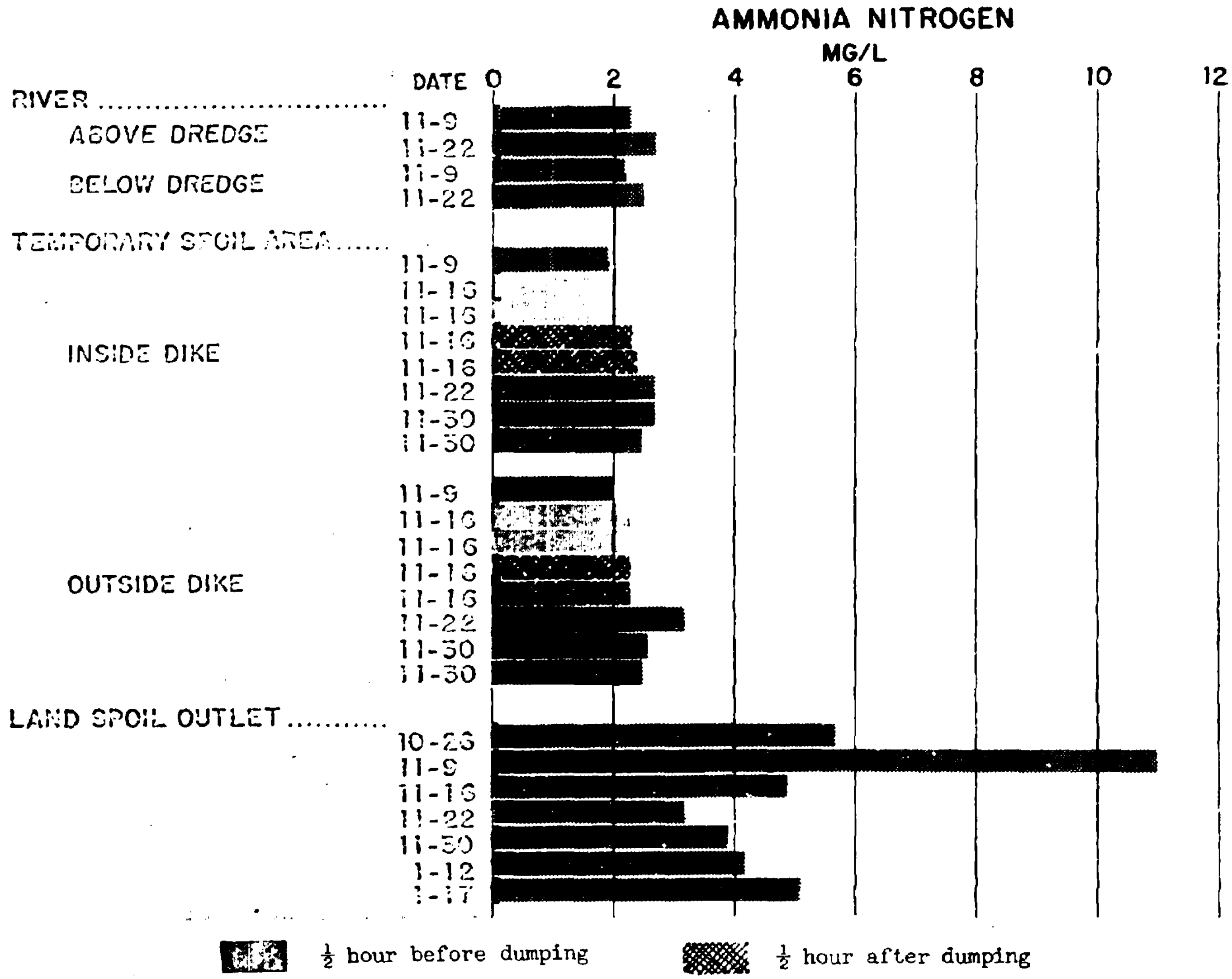


Figure 4

CALUMET RIVER DREDGING STUDY - Water Sample Analysis, 1967-68

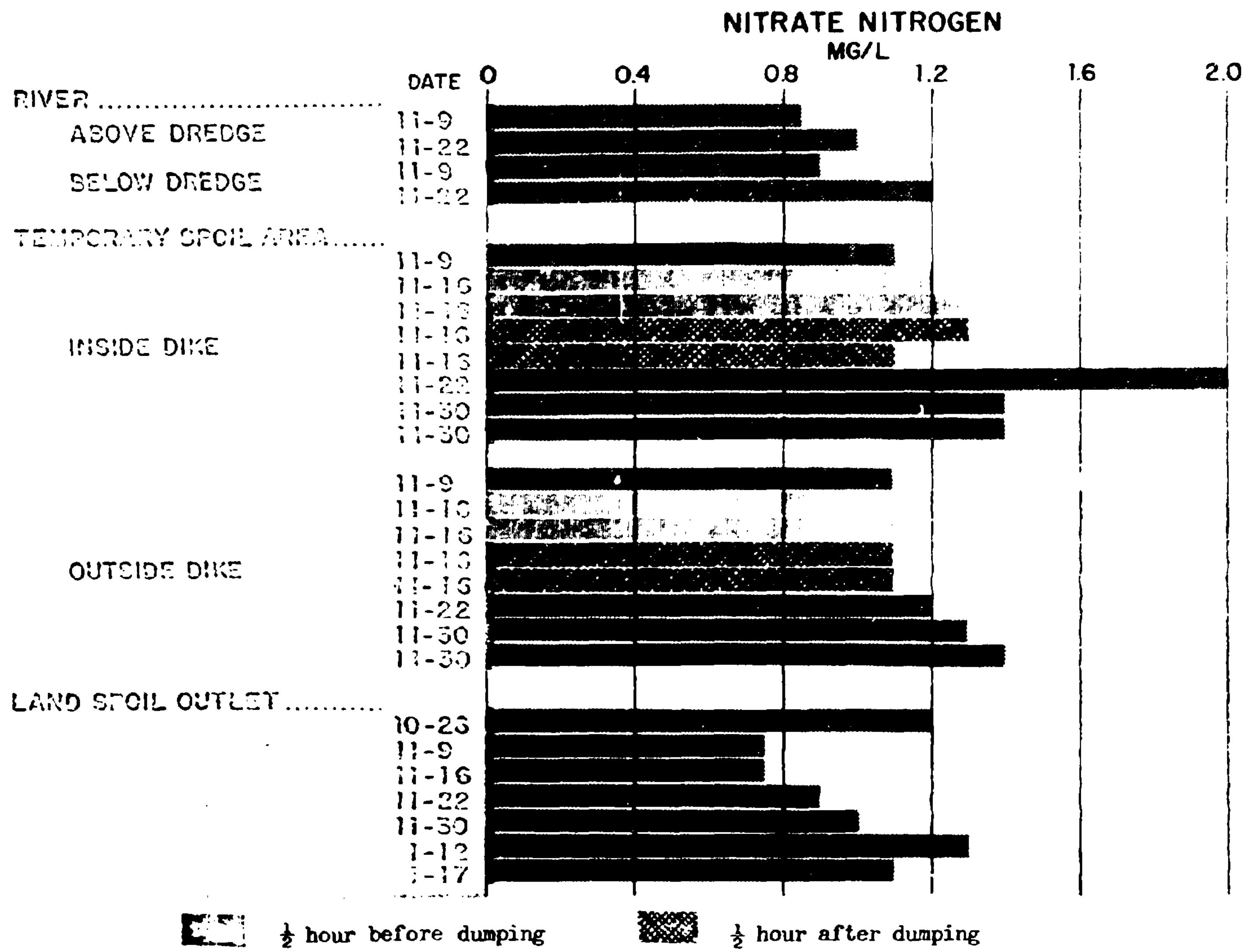


Figure 5

CALUMET RIVER DREDGING STUDY - Water Sample Analysis, 1967-68

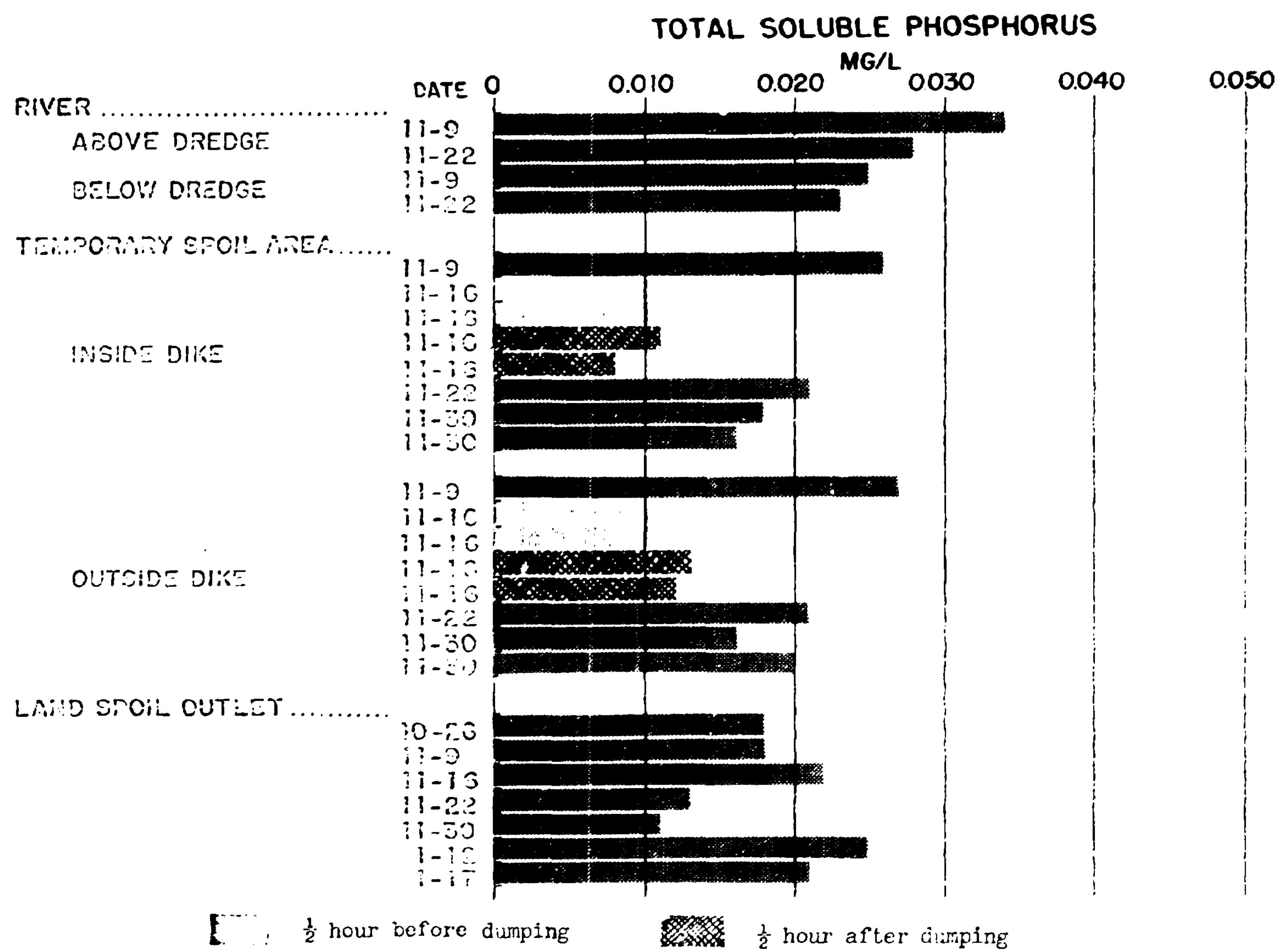


Figure 6

CALUMET RIVER DREDGING STUDY - Water Sample Analysis, 1967-68

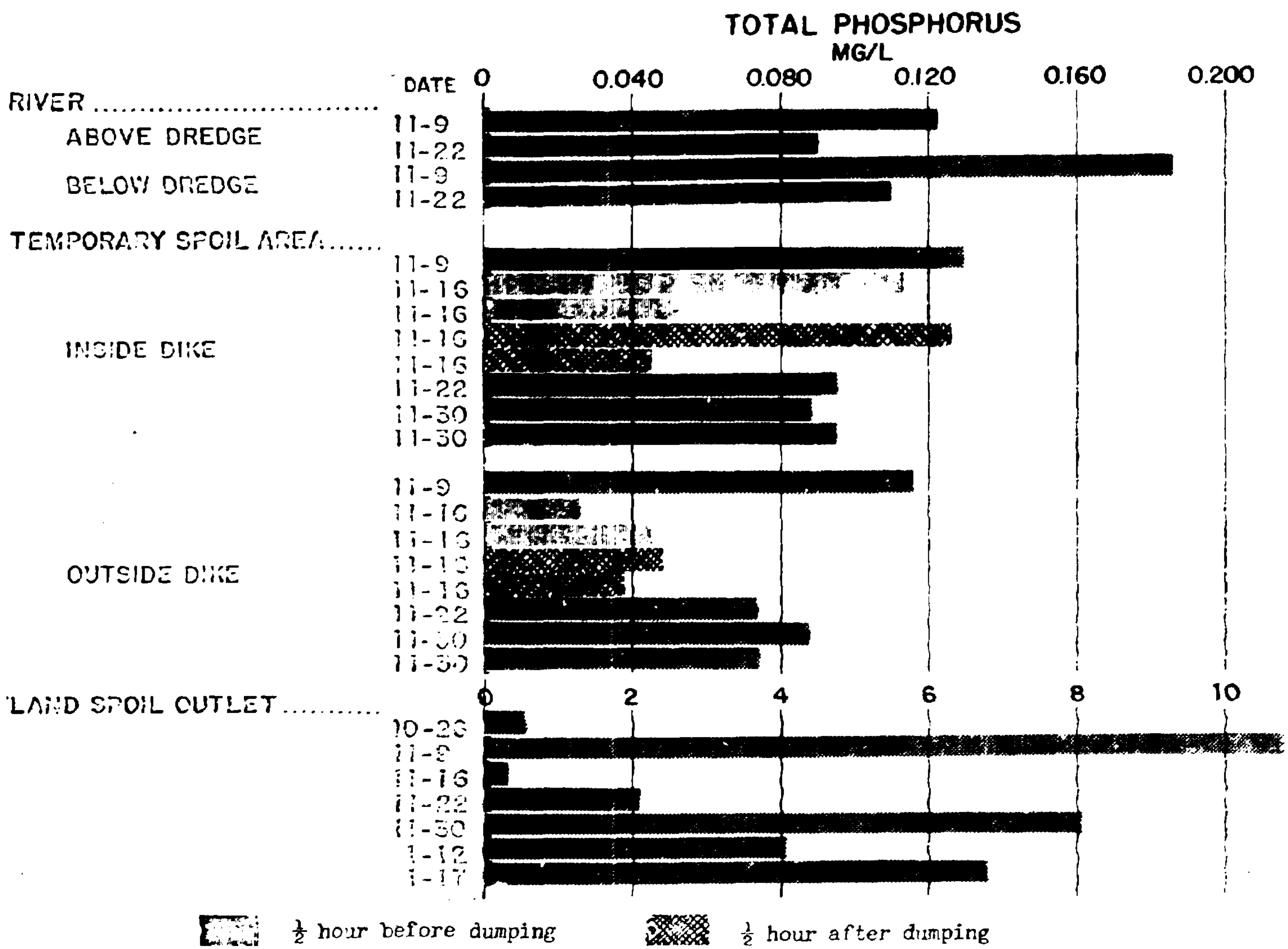


Figure 7

CALUMET RIVER DREDGING STUDY - Water Sample Analysis, 1967-68

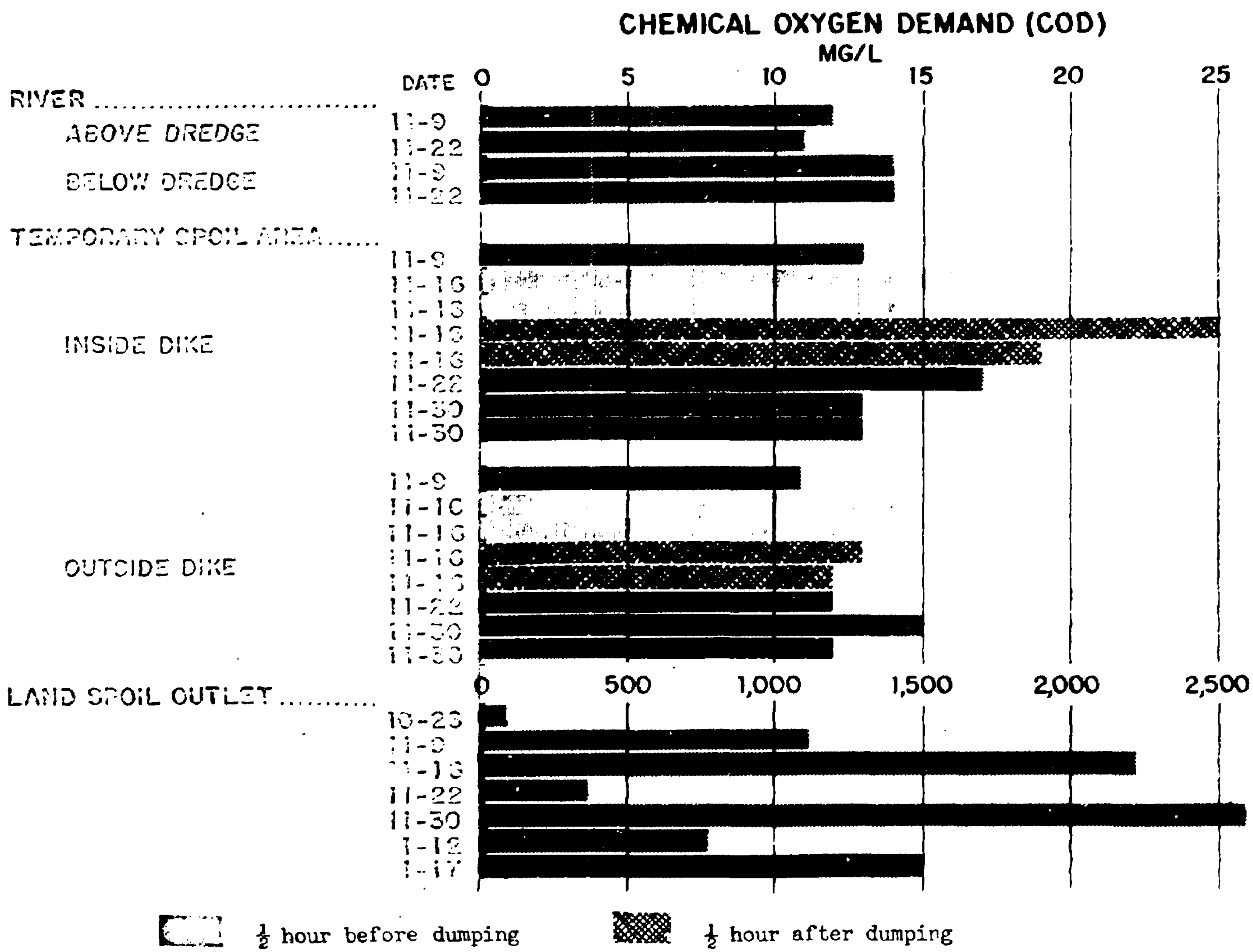


Figure 8

CALUMET RIVER DREDGING STUDY - Water Sample Analysis, 1967-68

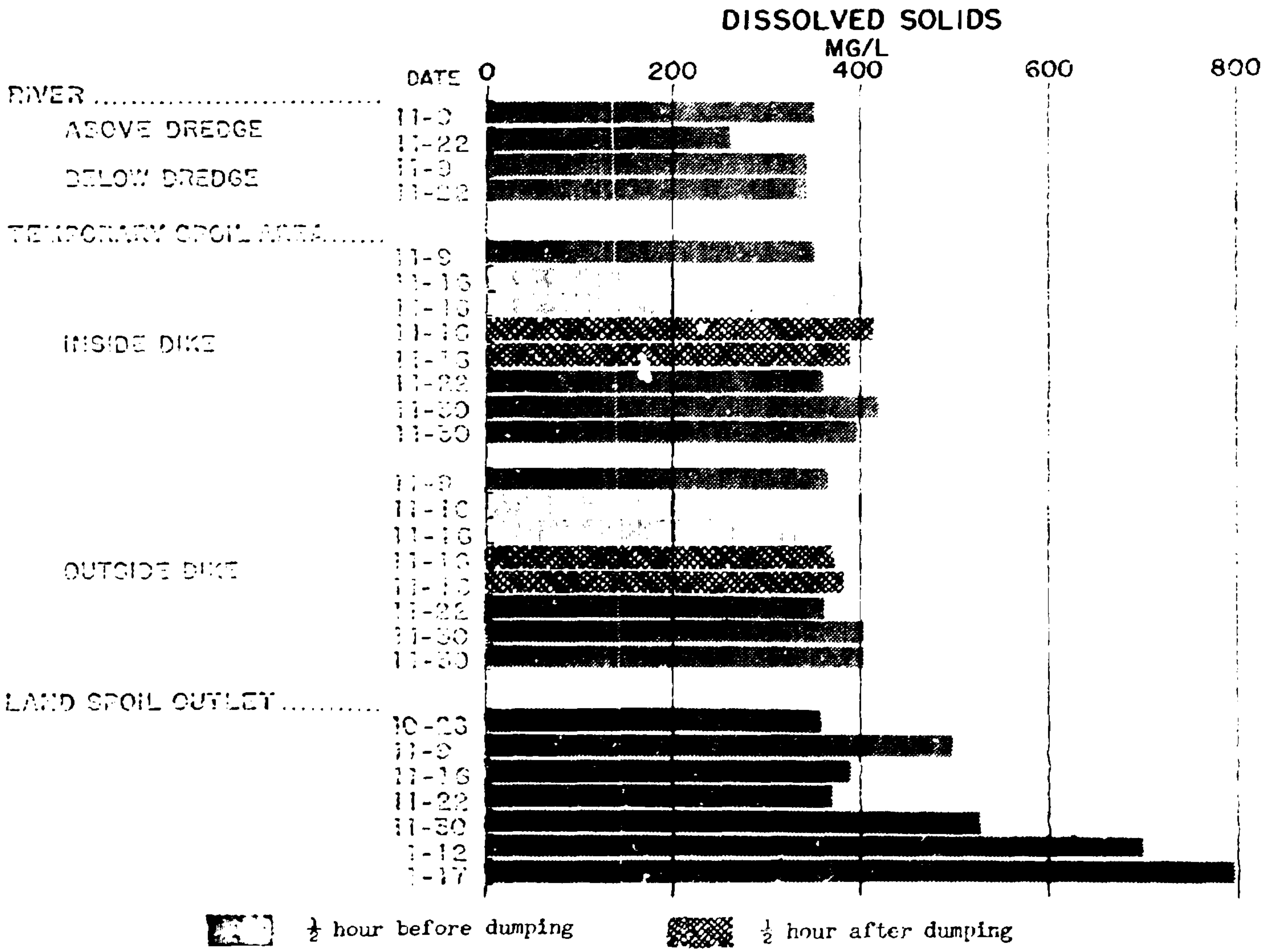


Figure 9

CALUMET RIVER DREDGING STUDY - Water Sample Analysis, 1967-68

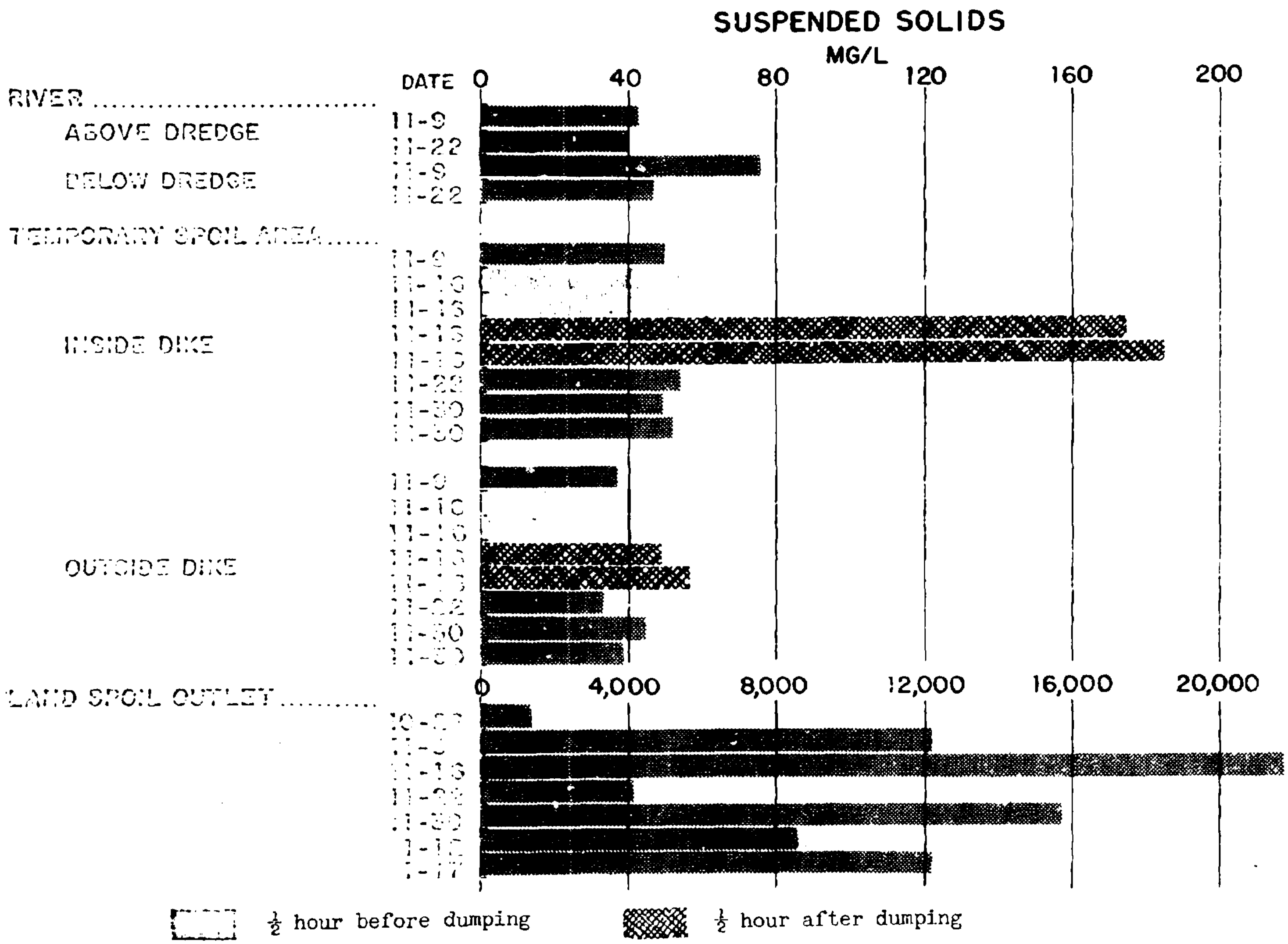


Figure 10

CALUMET RIVER DREDGING STUDY - Water Sample Analysis, 1967-68

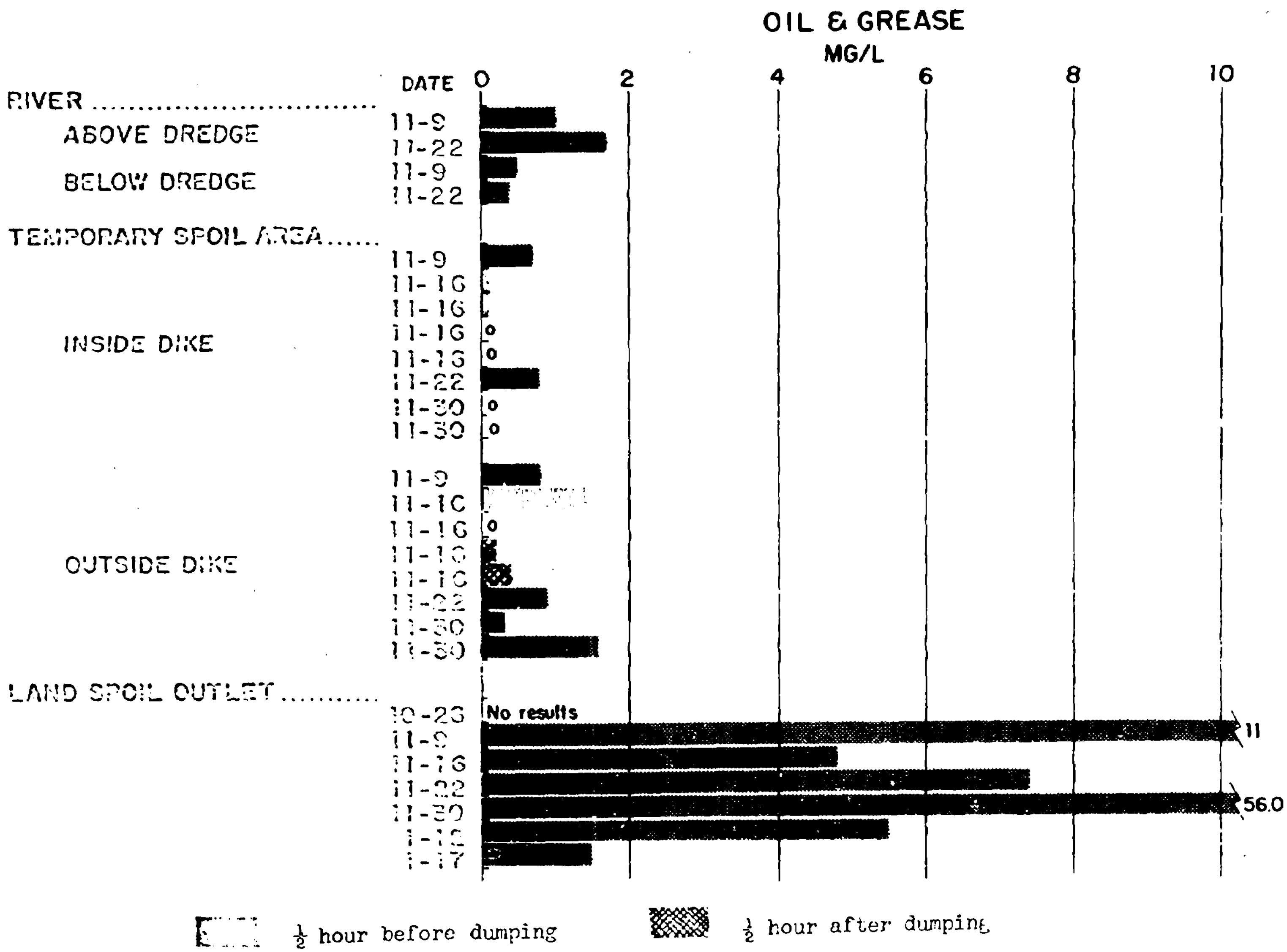


Figure 11

CALUMET RIVER DREDGING STUDY - Water Sample Analysis, 1967-68

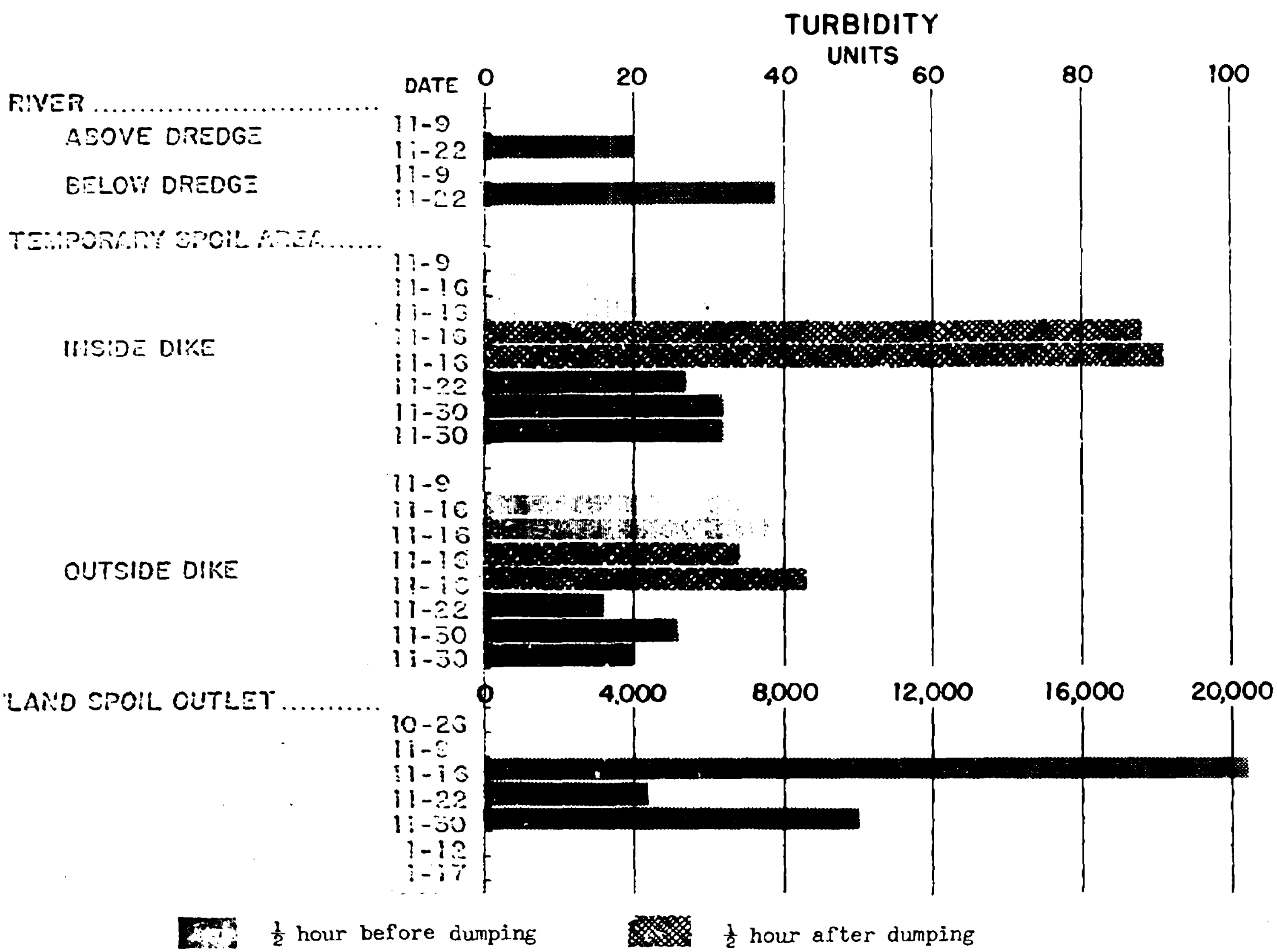


Figure 12

APPENDIX A9

GREEN BAY PILOT STUDY

GREEN BAY, WISCONSIN

1967

Prepared by
United States Department of the Interior
Federal Water Pollution Control Administration
Great Lakes Region
Chicago, Illinois
March 1968

TABLE OF CONTENTS

FIGURES

FIGURES (Continued)

TABLES

GREEN BAY PILOT STUDY

INTRODUCTION

The Green Bay area is one of eight sites in the Great Lakes selected by the U. S. Army Corps of Engineers for joint study with FWPCA of alternate procedures for the disposal of polluted dredging materials and the effects of these disposal techniques on water quality. This report covers the 1967 FWPCA sampling study in Green Bay.

As part of the pilot program, the channel from the C&NW Railroad Bridge to Long Tail Point was deepened under a contract that commenced on November 8, 1966 and was completed September 26, 1967. Under this contract, 632,000 cubic yards of dredgings were used (1) to fill a 380 acre diked land spoil site at Atkinson Marsh, and (2) to construct a dike inclosing a 230 acre bay spoil area adjoining the entrance channel in the bay, northeast of Grassy Island (see Figure 1). Material dredged from the Fox River channel by two clamshell dredges was placed in a temporary spoil area in the bay, then pumped to the land spoil area by a hydraulic dredge. The temporary spoil area consisted of a sump, 200 ft. by 750 ft., dredged to a depth of approximately 25 feet below the natural bottom of the bay. The hydraulic dredge, working in the channel from the mouth of the river to Grassy Island, pumped directly to the diked land spoil area. The dike in the bay was constructed by hydraulic dredge with material taken from the channel between Grassy Island and Long Tail Point.

1967 SAMPLING PROGRAM

Bottom sediments and water samples from the channel and sump area and water samples from the diked land spoil area were collected for the study. Water samples were also collected in the ditches on each side of

Tower Road, south of the diked land spoil area to determine if there was seepage through the dike. No samples were collected from the 230 acre diked area in the bay. Sampling points are shown in Figures 2 to 5.

CONCLUSIONS

1. Bottom sediments in the channel and sump have a high chemical oxygen demand and high concentration of oil and grease, total phosphorus, soluble phosphorus and total nitrogen.

2. Dredging operations in the sump area caused significant increase in conductivity, alkalinity, turbidity, total phosphorus, nitrogen and suspended solids, in the overlying water.

3. Turbidity and suspended solids were effectively reduced by detention in the land spoil area. Concentrations of other constituents in the overflow were generally equivalent to or higher than concentrations inside the spoil area, based on one set of comparative samples.

4. Based on the information available, it appears that there was very little seepage of pollutants through the dike inclosing the land spoil area.

CHRONOLOGY

April 13, 1967	Season's dredging operations started in the Fox River.
May 4, 1967	Dredging continues in the river. Nine bottom sediment samples collected, seven from the river and one each from the sump and a scow. Eight water samples collected from river and sump area.

May 18, 1967 — Hydraulic dredge started operating in the sump area.

July 17, 1967 — Dredging operations continue in the river and sump area. Six bottom sediment samples collected from the sump area.

July 18, 1967 — Dredging operations continue on the river and sump area. Three water samples collected of overflow from the diked land spoil area.

July 31, 1967 — Dredging operations continue in the river and in the channel north of Grassy Island. Two water samples collected from the overflow from the land spoil area.

August 3, 1967 — Dredging operations in the river completed. Construction of dike in bay north of Grassy Island continues.

August 17, 1967 — Seven water samples collected at the diked land spoil area, one from the outlet pipe, two from the land spoil area and four from two ditches south of the spoil area.

September 29, 1967 — All dredging operations completed for the season.

October 11, 1967 — Nine water samples collected at the land spoil area, three from inside the dike and six in the two ditches south of the spoil area. There was no overflow from the area.

DISCUSSION OF DATA

Bottom Sediments. Figures 6 - 10 show graphically most of the data obtained from analyses of bottom sediments in the river and bay channel, the sump area in Green Bay and from one scow load of dredgings. This data has also been tabulated and is shown in Tables 1 and 3.

At River Mile (RM) 1, all the chemical and physical constituents in Figures 6 - 10, except total solids, are considerably lower than the concentrations shown at each River Mile immediately above and below this point. Although dredging operations started on April 13, 1967 in the vicinity of RM 1, the area was not sampled until May 4, 1967. It is apparent from the low concentrations shown that the sample at RM 1 was collected after the area had been dredged. Therefore, these data have been omitted from the following discussion.

Bottom sediments in the channel have a high chemical oxygen demand and high concentrations of oil and grease, total phosphorus, soluble phosphorus and total nitrogen. The concentrations were generally highest up river at RM 3 and decreased fairly uniformly into the bay to Bay Mile (BM) 3.

The following is a summary of May 4, 1967 bottom sediment data for the river and bay channel:

Parameter	Unit (Dry Weight)	Maximum	Minimum
Total Solids	% of sample	30.5	13.0
Volatile Solids	% of total solids	23.7	14.8
Oil and Grease	mg/k	46,200	4,600
Total Phosphorus-P	mg/k	6,500	2,683
Soluble Phosphorus-P	mg/k	138	18.6
Chemical Oxygen Demand	mg/k	300,000	179,000
Total Nitrogen	mg/k	10,130	4,950

Parameter	Unit (Dry Weight)	Maximum	Minimum
Nitrogen (NO_3)	mg/k	16.2	9.9
Nitrogen (NH_3)	mg/k	1,240	60
Organic Nitrogen	mg/k	9,450	4,020
Sulfide	mg/k	830	240
Phenols	micrograms/gram	7.8	0.75
Immediate Dissolved Oxygen Demand	mg/k	94,600	21,400

Bottom sediments were collected in the sump area in Green Bay on May 4, 1967 and again on July 17, 1967. River dredgings were deposited in the sump routinely after April 13, and the hydraulic dredge had operated intermittently in the sump after May 18. A comparison of the samples collected on May 4 and July 17 is presented below. As would be expected, the data are similar to those shown above for the river sediments. It should be noted that on July 17, only two samples were taken from within the sump area (see Figure 3), with two samples taken on either side. The data (Table 3) show higher values in the sump for only ammonia nitrogen and soluble phosphorus.

BOTTOM SEDIMENT DATA IN THE SUMP AREA

Parameter	Unit (Dry Weight)	May 4, 1967 (one sample)	July 17, 1967 (Average of 6 samples)
Total Solids	% of sample	41.3	29.1
Volatile Solids	% of total solids	13.4	15.3
Oil and Grease	mg/k	4,200	13,855
Total Phosphorus-P	mg/k	1,910	1,165
Soluble Phosphorus-P	mg/k	45	7.8
Chemical Oxygen Demand	mg/k	122,000	167,350
Total Nitrogen	mg/k	2,690	-

Parameter	Unit (Dry Weight)	May 4, 1967 (one sample)	July 17, 1967 (Average of 6 samples)
Nitrogen NO_3	mg/k	4.4	8.5
Nitrogen NH_3	mg/k	660	469
Organic Nitrogen	mg/k	2,350	3,526

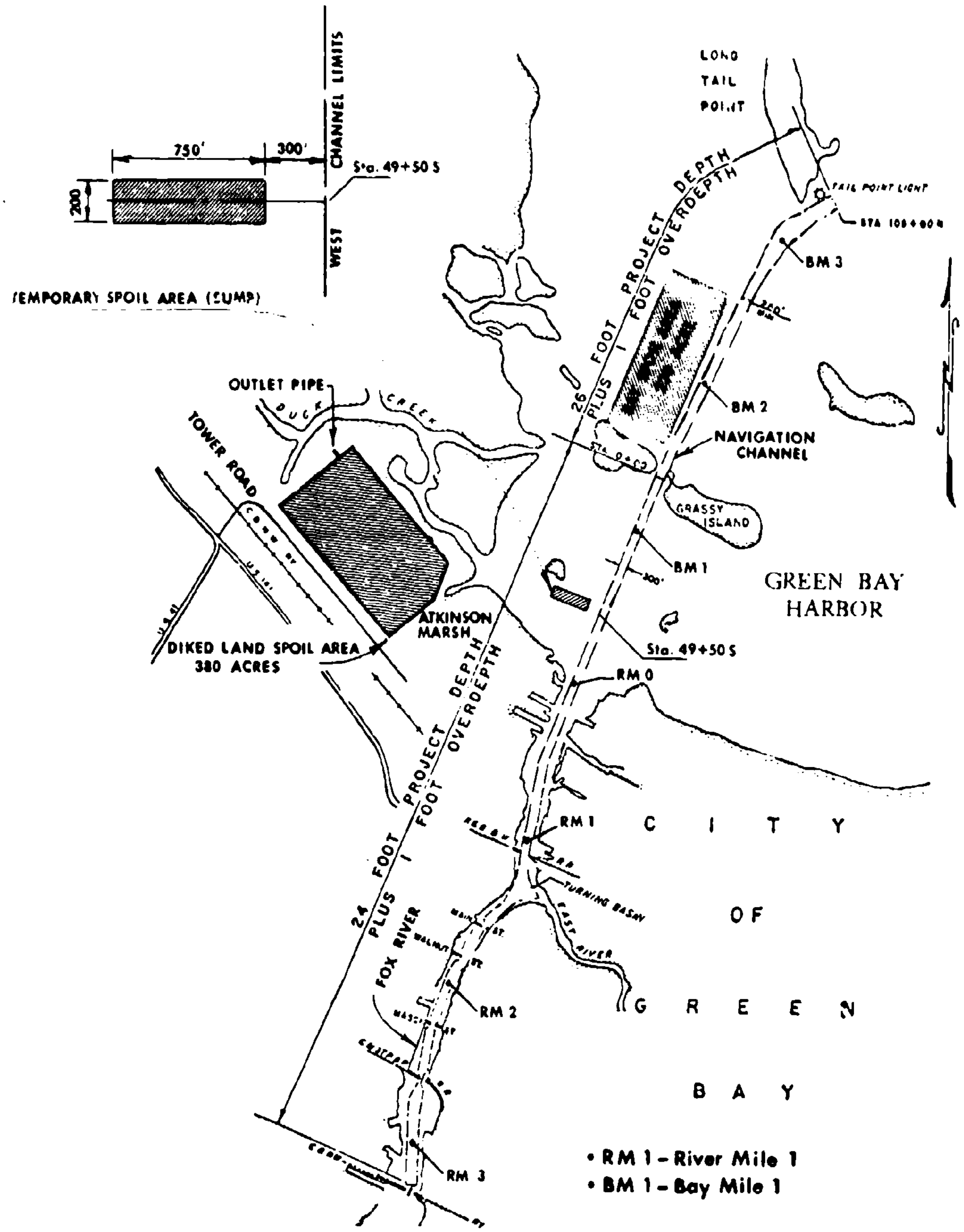
Water Quality. Figures 11-19 show graphically most of the data obtained from analyses of water samples collected from the river and bay channel, the sump in the bay and the diked land spoil area. This data is also tabulated and is shown in Tables 2 and 4-6.

Water Quality in the Sump Area. On May 4, 1967, water samples were collected in the river and at the sump area. Analyses of these samples, Table 2 and Figures 11-19 shows that water quality in the sump area after the disposal of dredging materials was much worse than water quality in the river or bay channel. The dredging operation had a noticeable effect on conductivity, alkalinity, turbidity, total phosphorus, nitrogen and suspended solids; all increased significantly as might be expected. There was a particularly significant increase in ammonia and total nitrogen which is to be expected when waters are first contaminated by organic matter in an anaerobic state.

Water Quality in the Land Spoil Area. Water samples were collected at the land spoil area to determine the effectiveness of the dike to retain the various chemical and physical constituents in the dredging materials placed in the spoil area by the hydraulic dredge. Water samples were collected on July 17, 18 and 31 and on August 1 and 17, 1967. Analyses of these samples (Figures 11-19 and Tables 2 and 4-6) shows a considerable variation of effects on the quality of water discharging from the dike through the outlet pipe. The data collected on August 17, 1967 which compares water quality inside the diked area, at the overflow pipe, and in the ditches illustrates the effectiveness of the dike to retain the various constituents of the bottom sediments. A comparison of concentrations inside the dike to those flowing through the outlet pipe are summarized below:

Parameter	Units	Inside Dike at 2 points	Outlet Pipe
Turbidity	APHA	24 - 10.0	9.0
Total Phosphorus-P	mg/l	0.59 - 0.28	0.72
Soluble Phosphorus-P	mg/l	0.18 - 0.12	0.18
Nitrogen NO_3	mg/l	2.9 - 2.1	1.9
Nitrogen NH_3	mg/l	5.8 - 4.7	6.9
Nitrogen, Organic	mg/l	4.2 - 3.6	6.1
Dissolved Solids	mg/l	386 - 420	406
Suspended Solids	mg/l	117 - 38	92
Chemical Oxygen Demand	mg/l	98 - 78	107

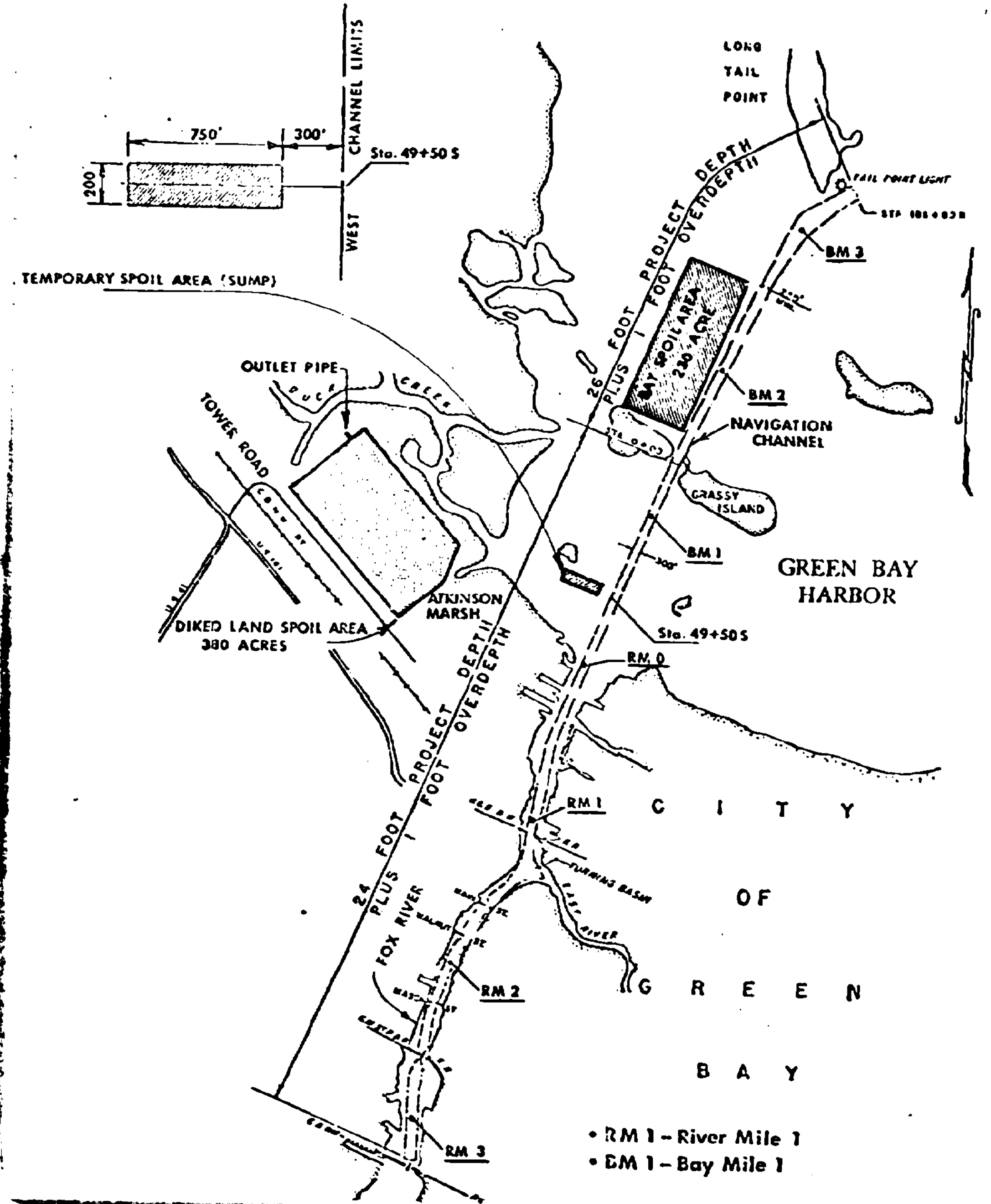
The above data shows that only turbidity was effectively controlled by the dike and that some of the chemical constituents of the dredgings such as total phosphorus, ammonia nitrogen, organic nitrogen and chemical oxygen demand were higher at the outlet pipe than inside the dike. A comparison of chemical and physical concentrations inside the dike with those in the ditches on each side of Tower Road for August 17, 1967, show that with the exception of dissolved solids, the concentrations inside the dike were considerably higher than those in the ditches, indicating very little seepage of constituents through the dike. On October 11, 1967, 9 samples were collected both inside and outside the diked area (Figure 5). The analytical results are shown in Table 6. Excluding the results from sampling station number 6, the phosphorus and nitrogen levels, suspended solids and turbidity are all generally higher inside the diked area which indicates again the effectiveness of the dike in limiting seepage through the dike.



GREEN BAY HARBOR

STUDY AREA

FIGURE 1



Sample No.	Location	Analysis
1	BM 3	Sed. - Water
2	BM 2	Sed. - Water
3	BM 1	Sed. - Water
4	RM 0	Sed. - Water
5	RM 1	Sed. - Water
6	RM 2	Sed. - Water
7	RM 3	Sed. - Water
8	Sump	Sed. - Water
9	Scow in River	Sed.

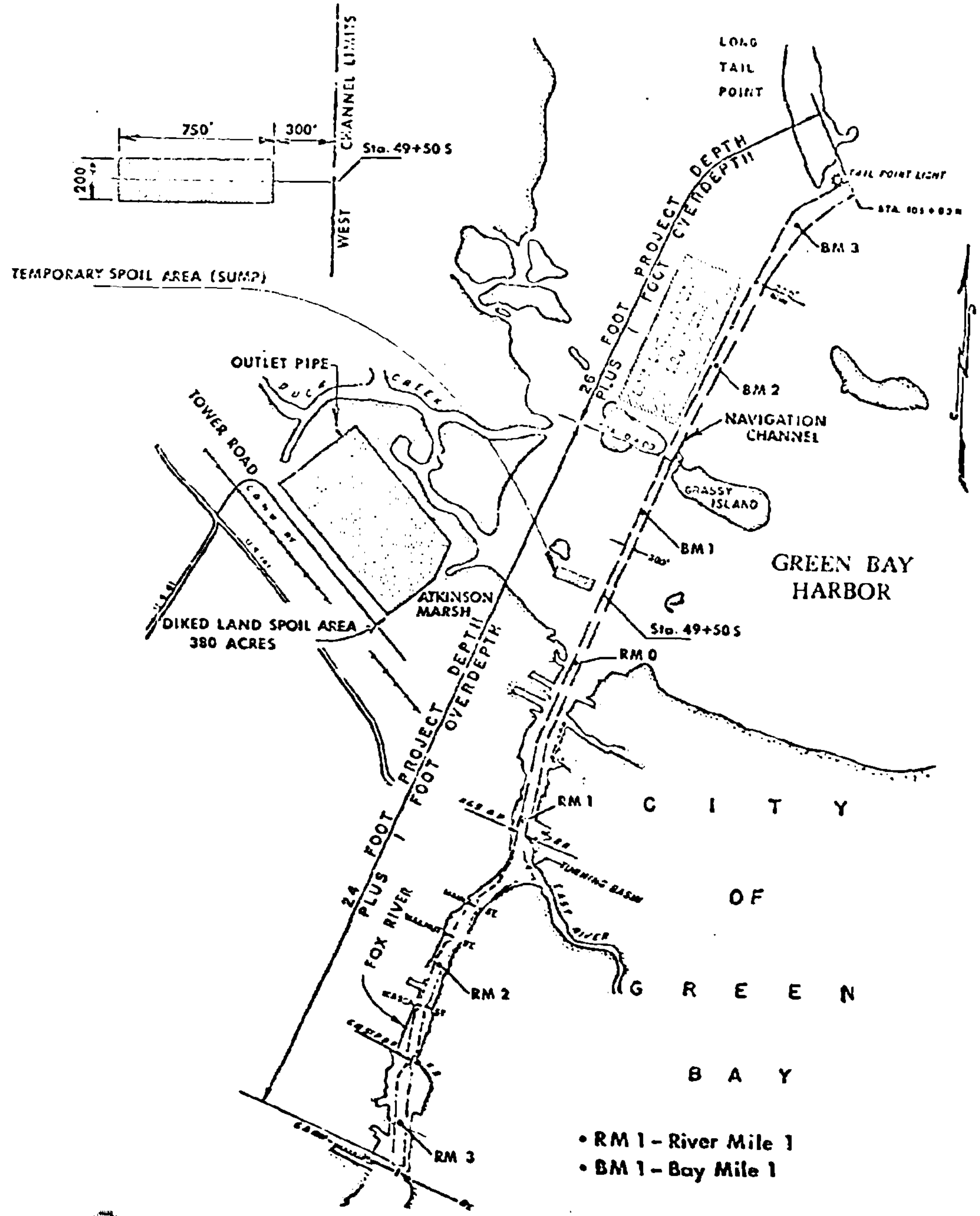
GREEN BAY HARBOR

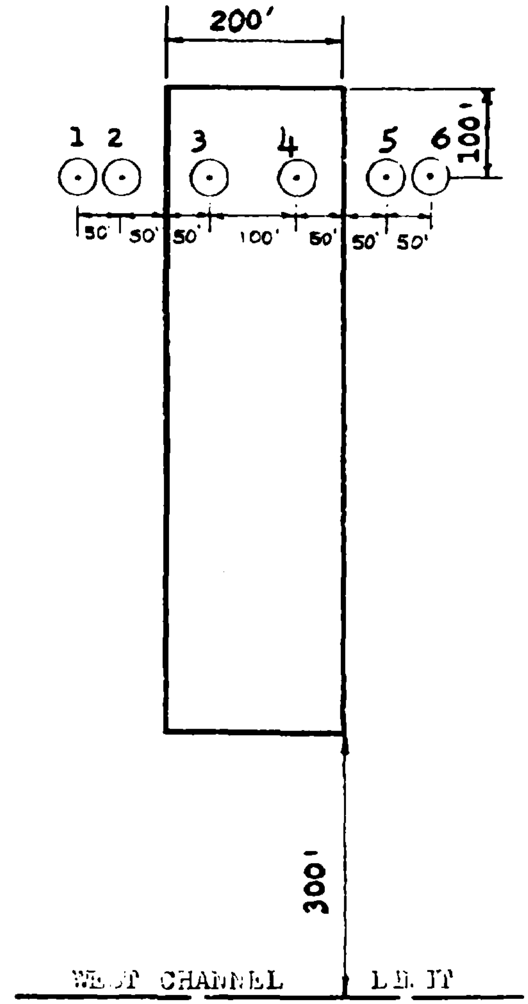
SAMPLING LOCATIONS

Bottom Sediments & Water

May 4, 1967

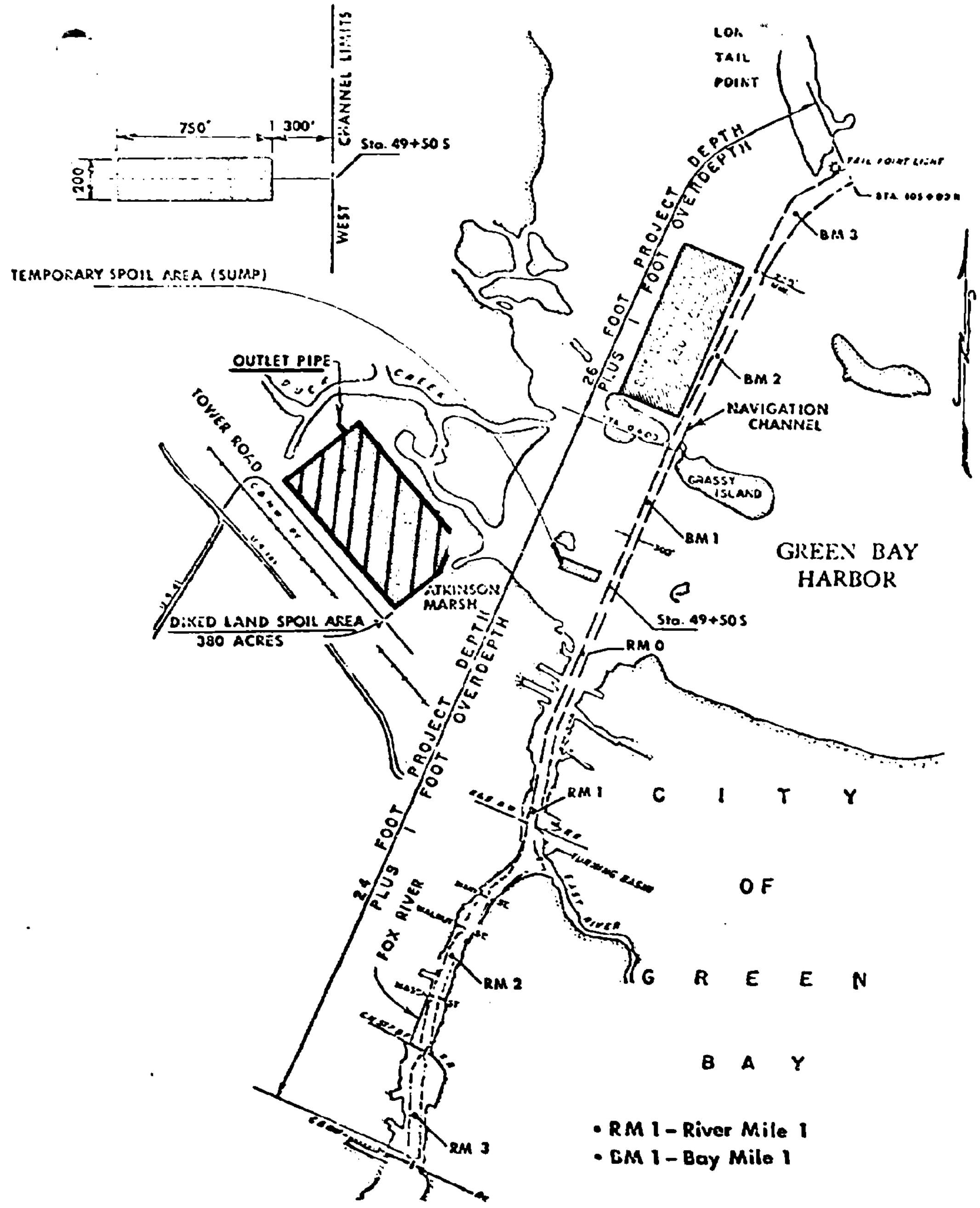
FIGURE 2





SUMP
GREEN BAY HARBOR
SAMPLING LOCATION
SUMP BOTTOM SEDIMENTS
JULY 17, 1967

FIGURE 3



[illegible]

July 17-1[illegible], 1967

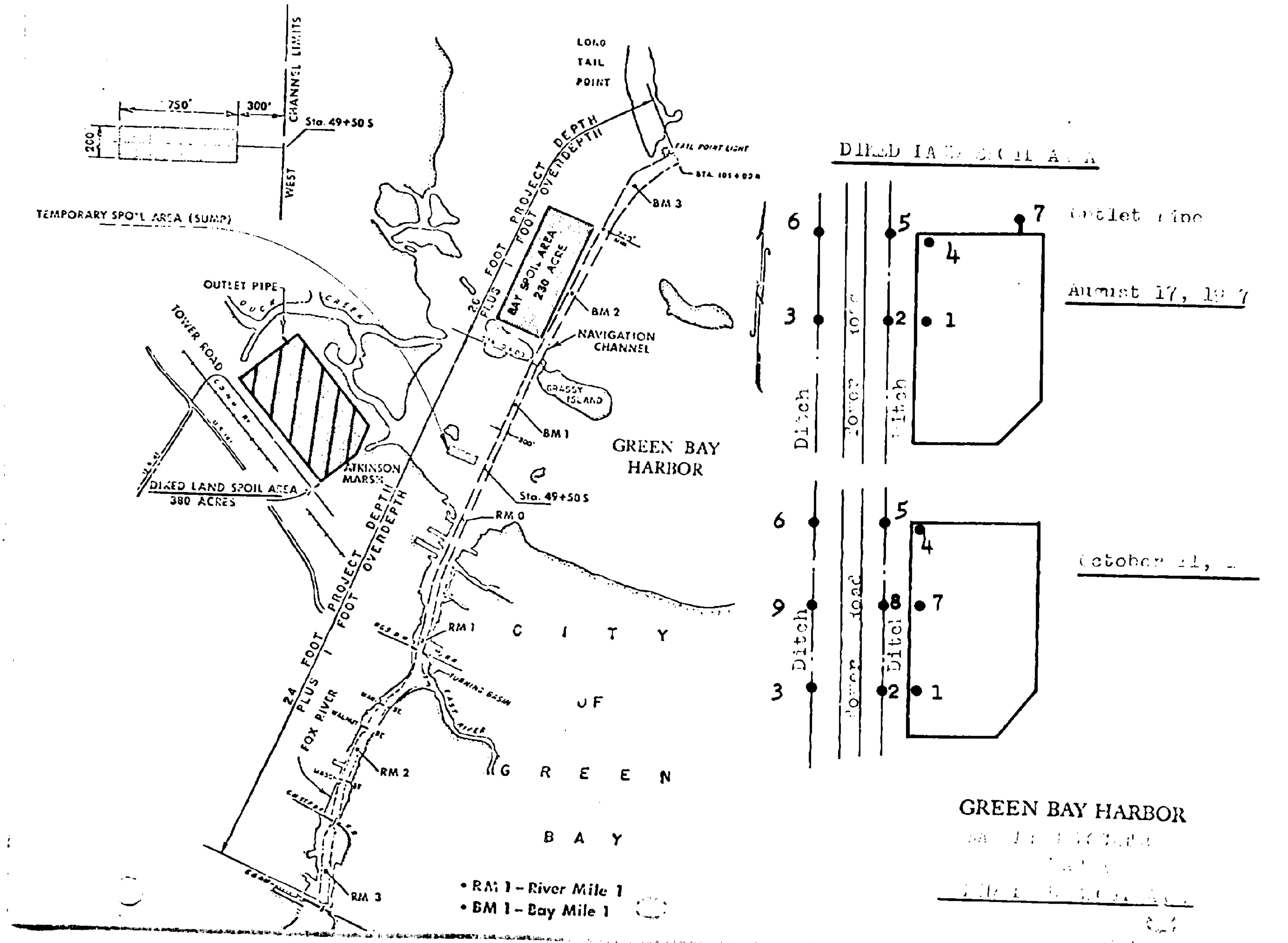
Sample No.	Date	Time
1	Jul 17	[illegible]
2	Jul 1[illegible]	[illegible]
3	Jul 1[illegible]	[illegible] AM

JULY 31-[illegible] 1, 1967

Sample No.	Date	Time
1	Jul 31	7:00 AM
2	Aug 1	[illegible]:00 [illegible]

GREEN BAY HARBOR
SA[illegible] LOCATIONS
[illegible] OUTLET PIPE
[illegible] AREA

[illegible] 4



TEMPORARY SPOIL AREA (SUMP)
750'
300'
200'
WEST CHANNEL LIMITS
Sta. 49+50 S
LONG TAIL POINT
TAIL POINT LIGHT
BM 3
BM 2
BM 1
NAVIGATION CHANNEL
BAY SPOIL AREA 230 ACRE
26 FOOT PROJECT DEPTH PLUS 1 FOOT OVERDEPTH
24 FOOT PROJECT DEPTH PLUS 1 FOOT OVERDEPTH
GRASSY ISLAND
GREEN BAY HARBOR
OUTLET PIPE
DUCK CREEK
TOWER ROAD
DIKED LAND SPOIL AREA 380 ACRES
ATKINSON MARSH
RM 0
RM 1
RM 2
RM 3
TURNING BASIN
EAST RIVER
FOX RIVER
CITY OF GREEN BAY
• RM 1 – River Mile 1
• BM 1 – Bay Mile 1
Outlet Pipe
Ditch
Road
6
5
7
4
3
2
1
9
8
GREEN BAY HARBOR

FOX RIVER-GREEN BAY SEDIMENT DATA, May 4, 1967

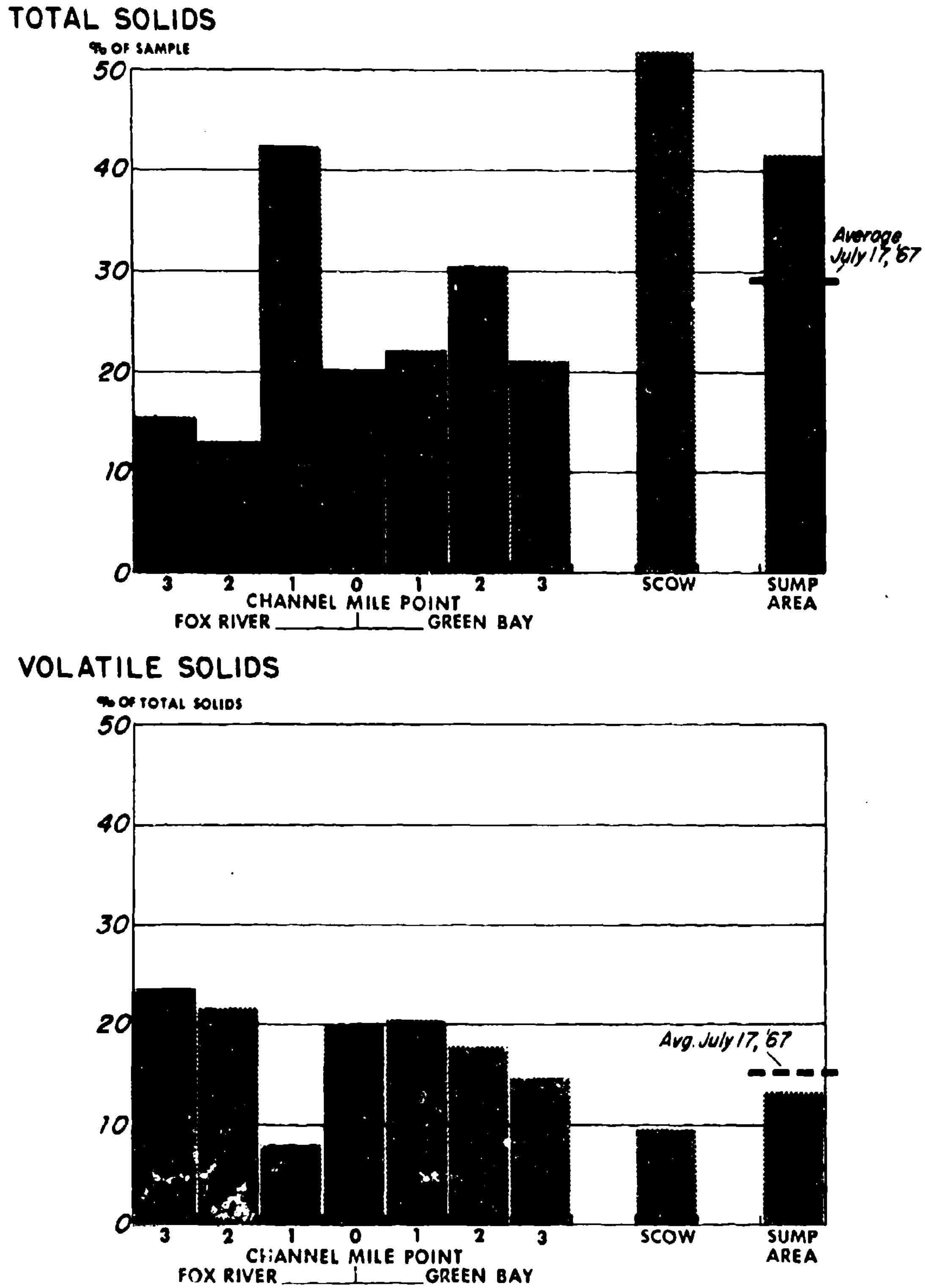
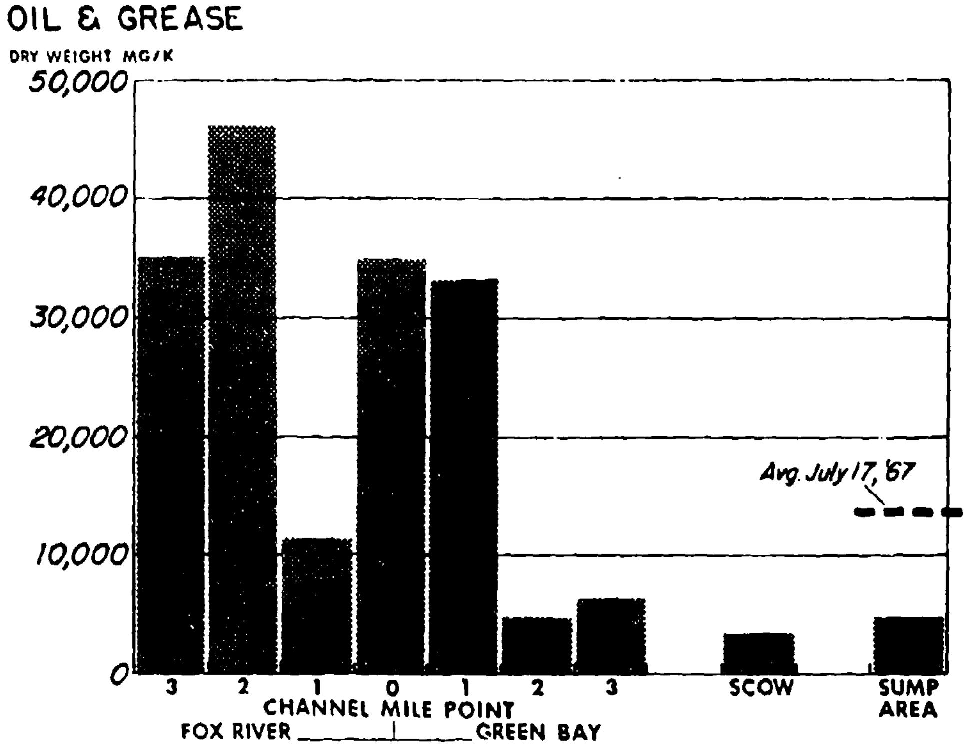


FIGURE 5

FOX RIVER-GREEN BAY SEDIMENT DATA, May 4, 1967



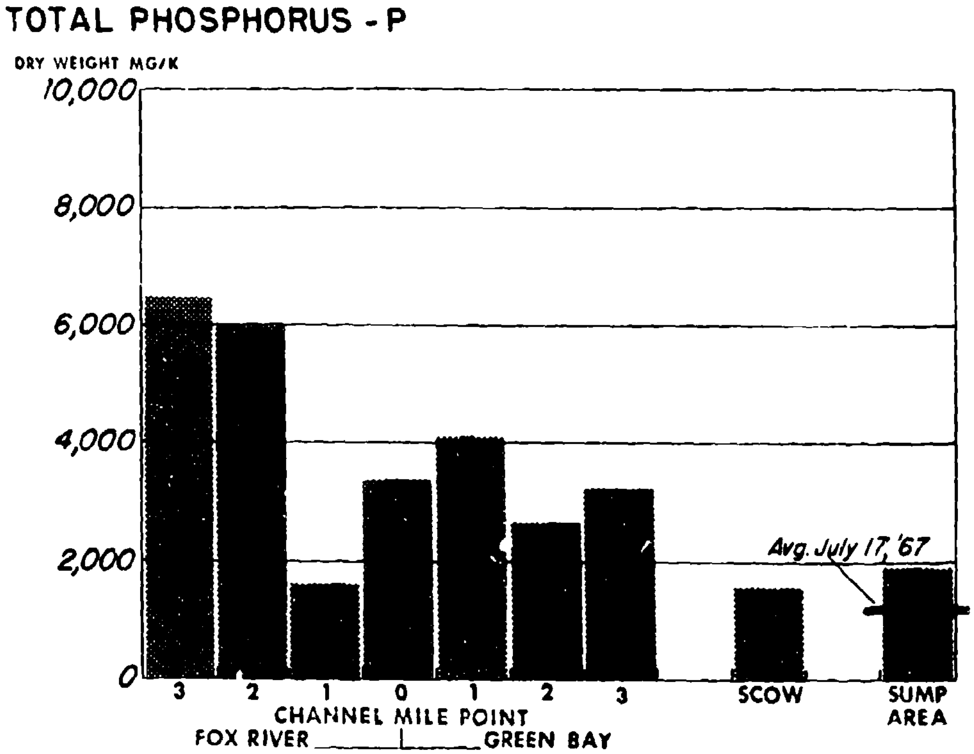
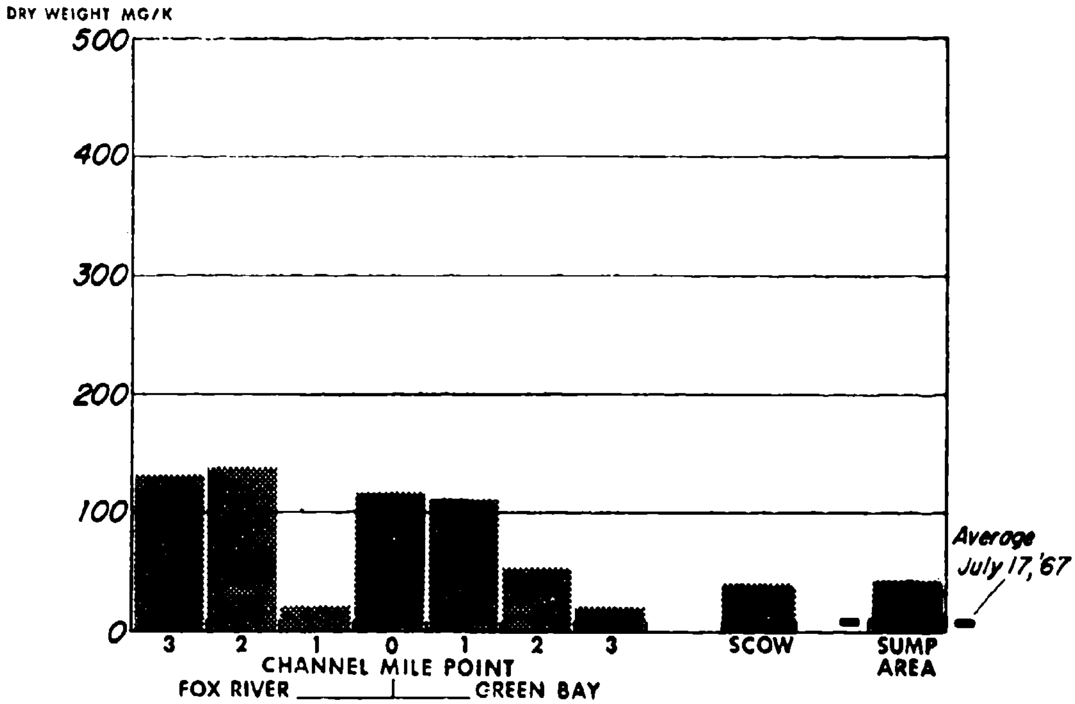


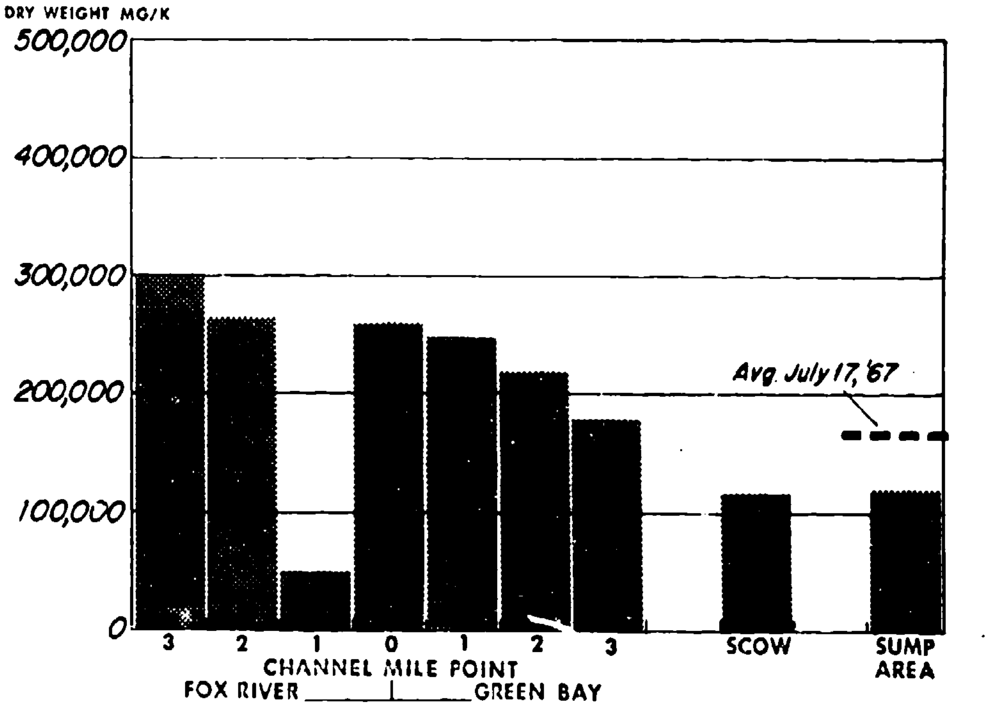
FIGURE 7

FOX RIVER-GREEN BAY SEDIMENT DATA, May 4, 1967

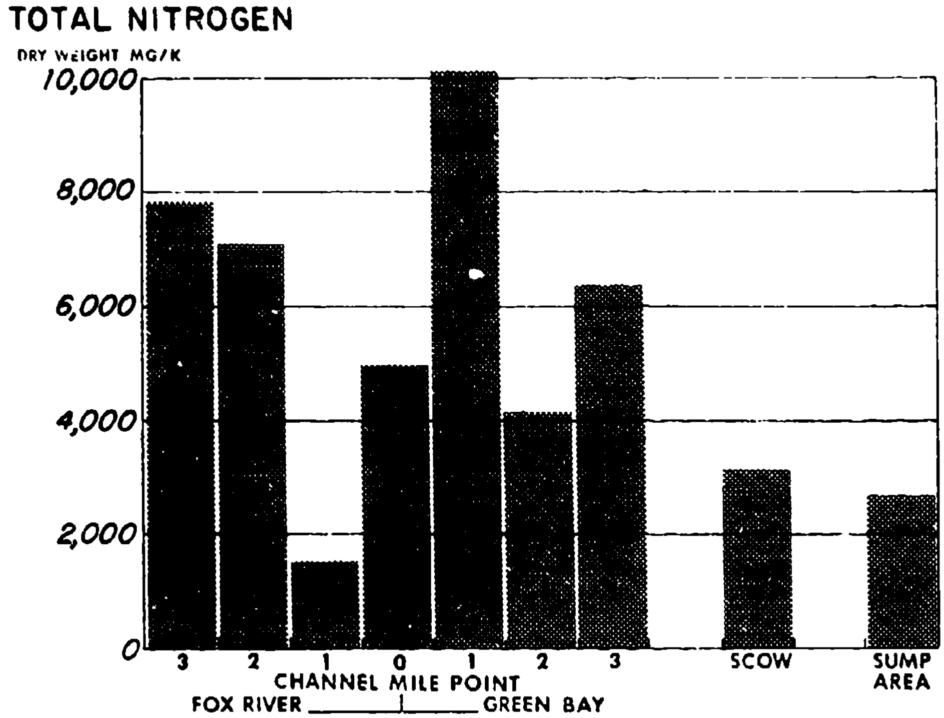
SOLUBLE PHOSPHORUS - P

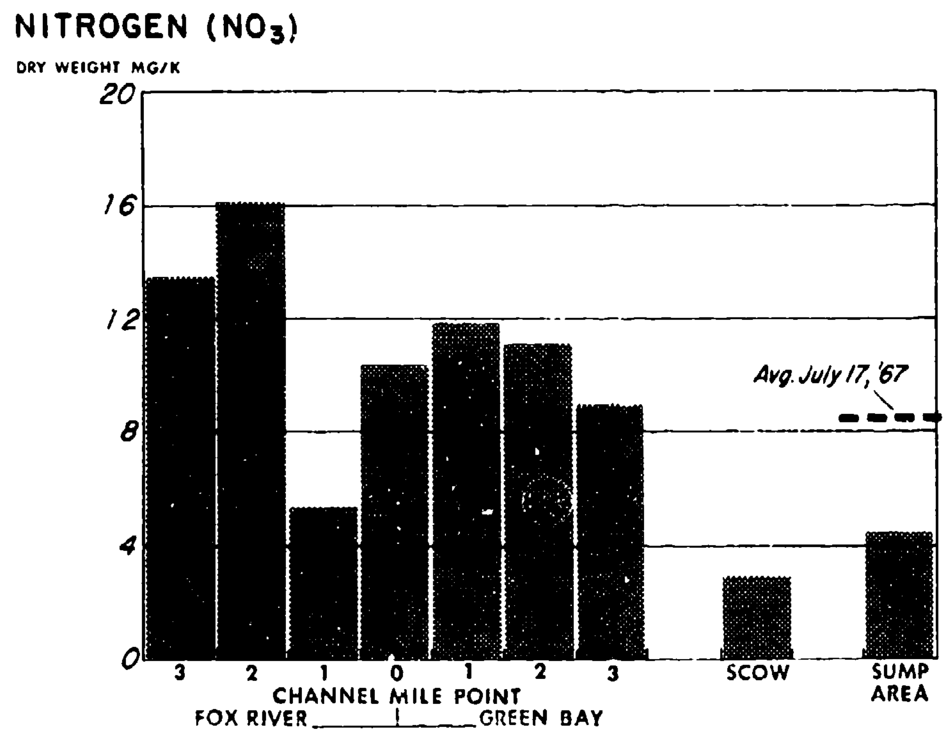


CHEMICAL OXYGEN DEMAND

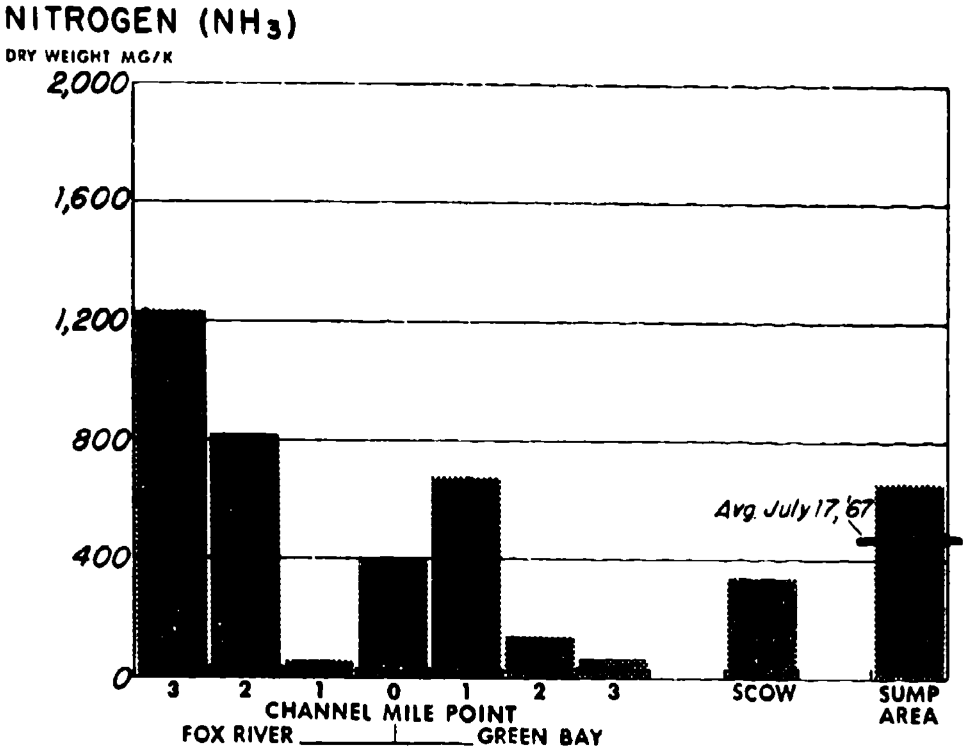


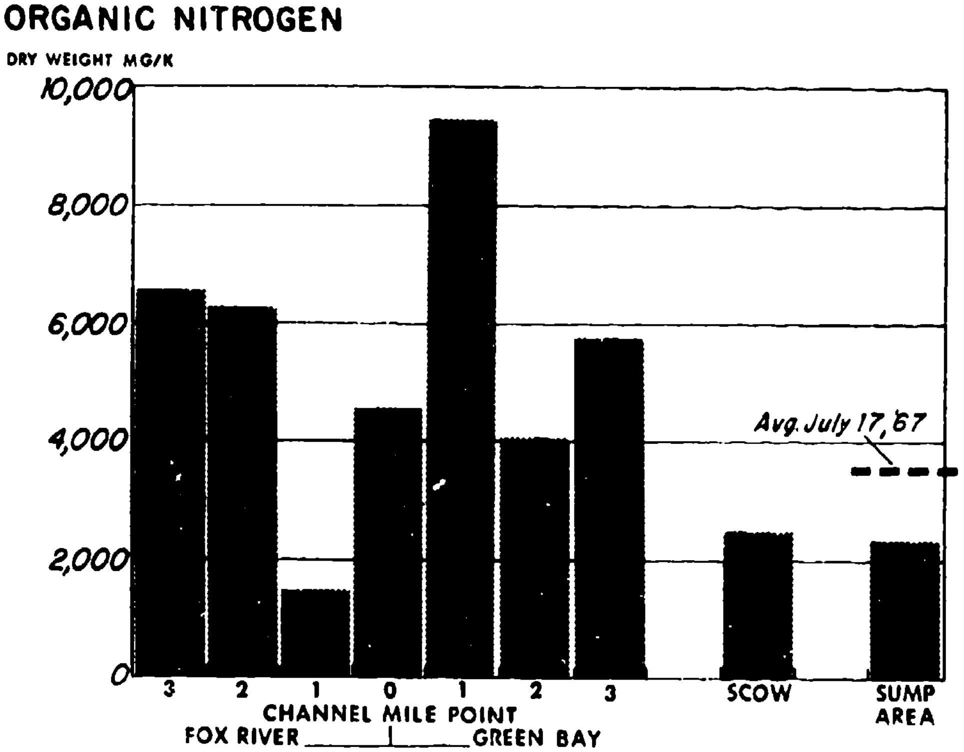
FOX RIVER-GREEN BAY SEDIMENT DATA, May 4, 1967



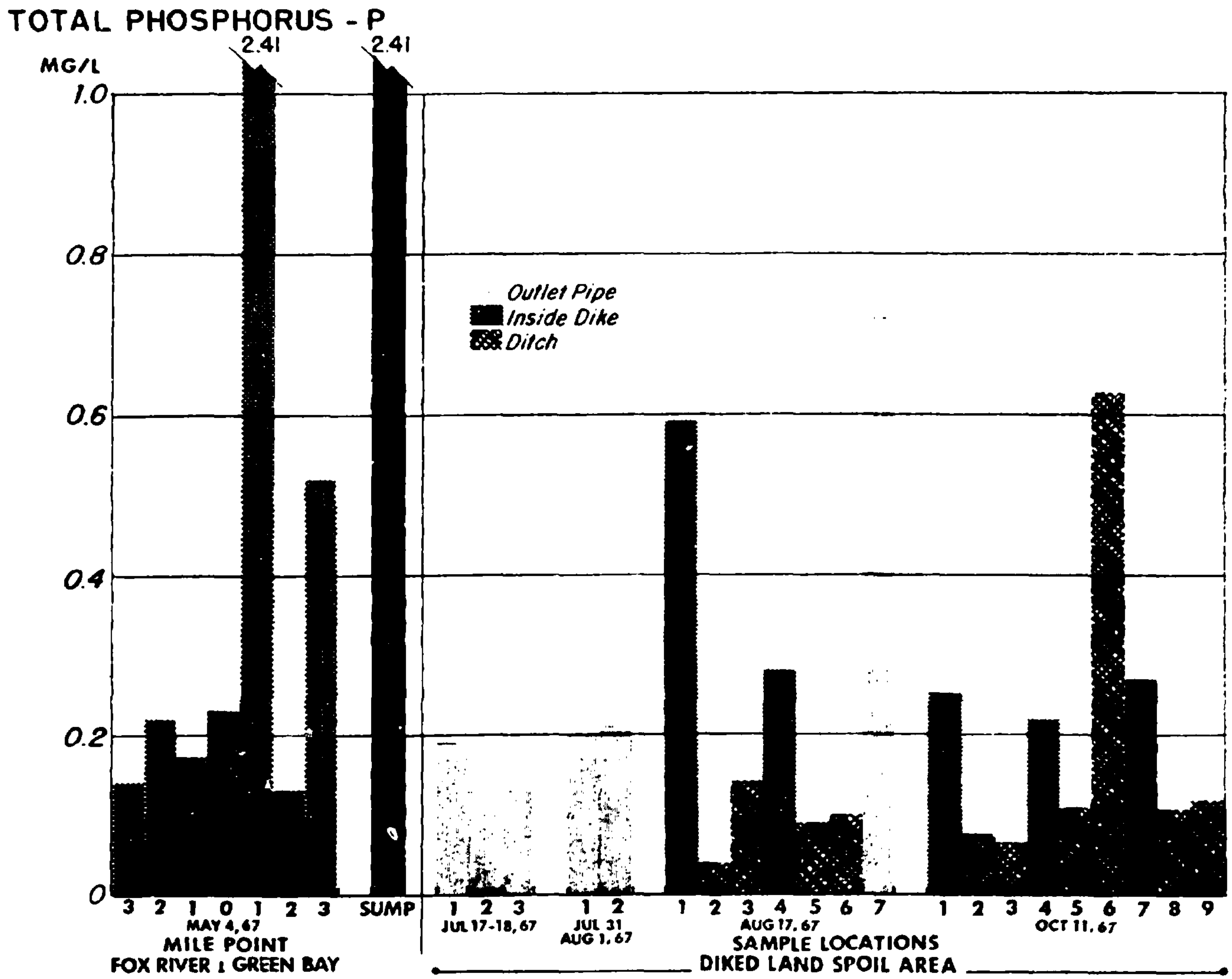


FOX RIVER-GREEN BAY SEDIMENT DATA, May 4, 1967





FOX RIVER-GREEN BAY & DIKED AREA WATER DATA



FIGURE]

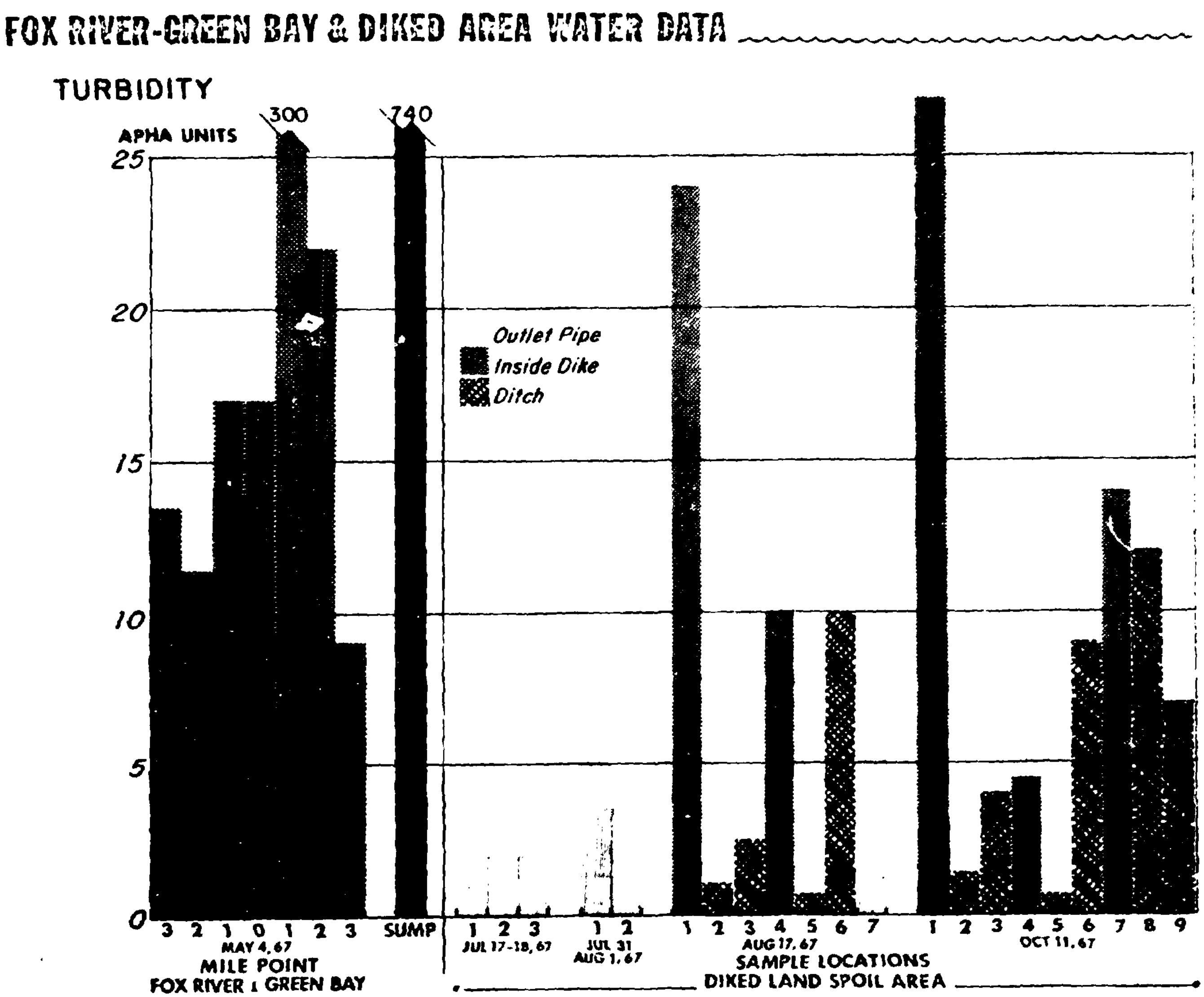
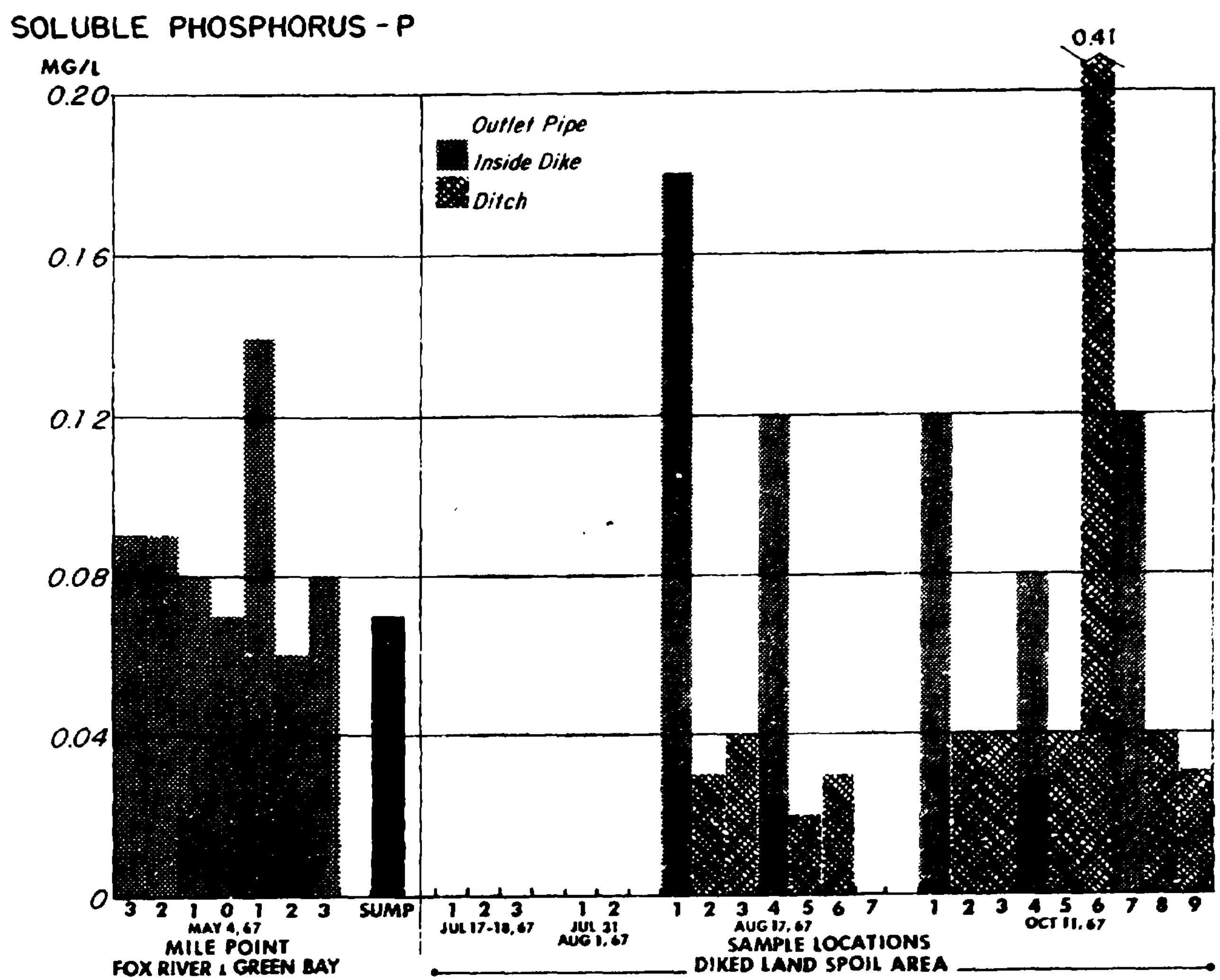

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA
TURBIDITY
APHA UNITS
300
740
25
20
15
10
5
0
Outlet Pipe
Inside Dike
Ditch
3 2 1 0 1 2 3
MAY 4, 67
MILE POINT
FOX RIVER & GREEN BAY
SUMP
1 2 3
JUL 17-18, 67
1 2
JUL 31
AUG 1, 67
1 2 3 4 5 6 7
AUG 17, 67
1 2 3 4 5 6 7 8 9
OCT 11, 67
SAMPLE LOCATIONS
DIKED LAND SPOIL AREA

FIGURE 12

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA



FIGURE

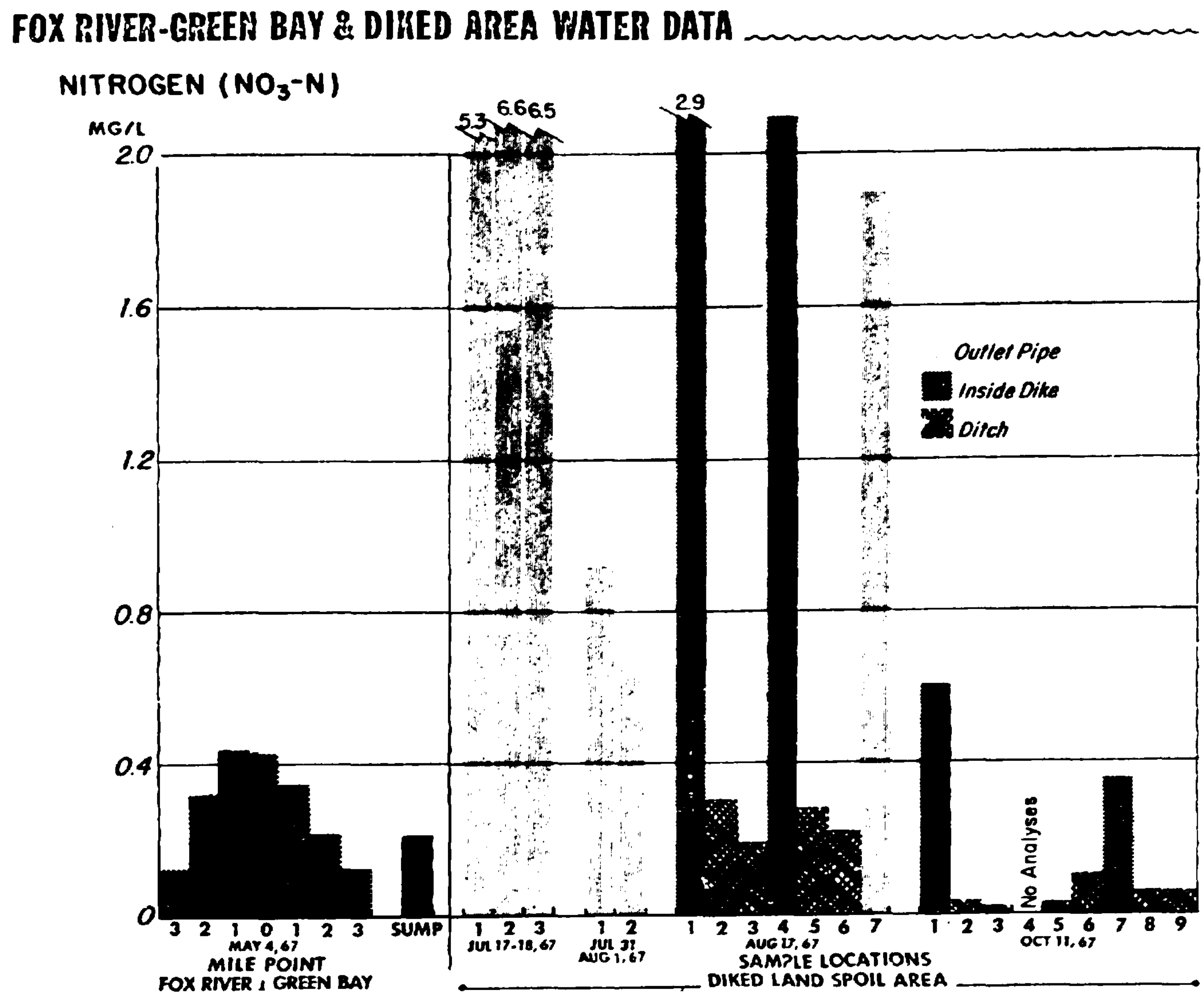

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA
NITROGEN (NO_3-N)
MG/L
2.0
1.6
1.2
0.8
0.4
0
5.3
6.6
6.5
2.9
Outlet Pipe
Inside Dike
Ditch
No Analyses
3 2 1 0 1 2 3
MAY 4, 67
MILE POINT
FOX RIVER & GREEN BAY
SUMP
1 2 3
JUL 17-18, 67
1 2
JUL 31 AUG 1, 67
1 2 3 4 5 6 7
AUG 17, 67
1 2 3 4 5 6 7 8 9
OCT 11, 67
SAMPLE LOCATIONS
DIKED LAND SPOIL AREA

FIGURE 14

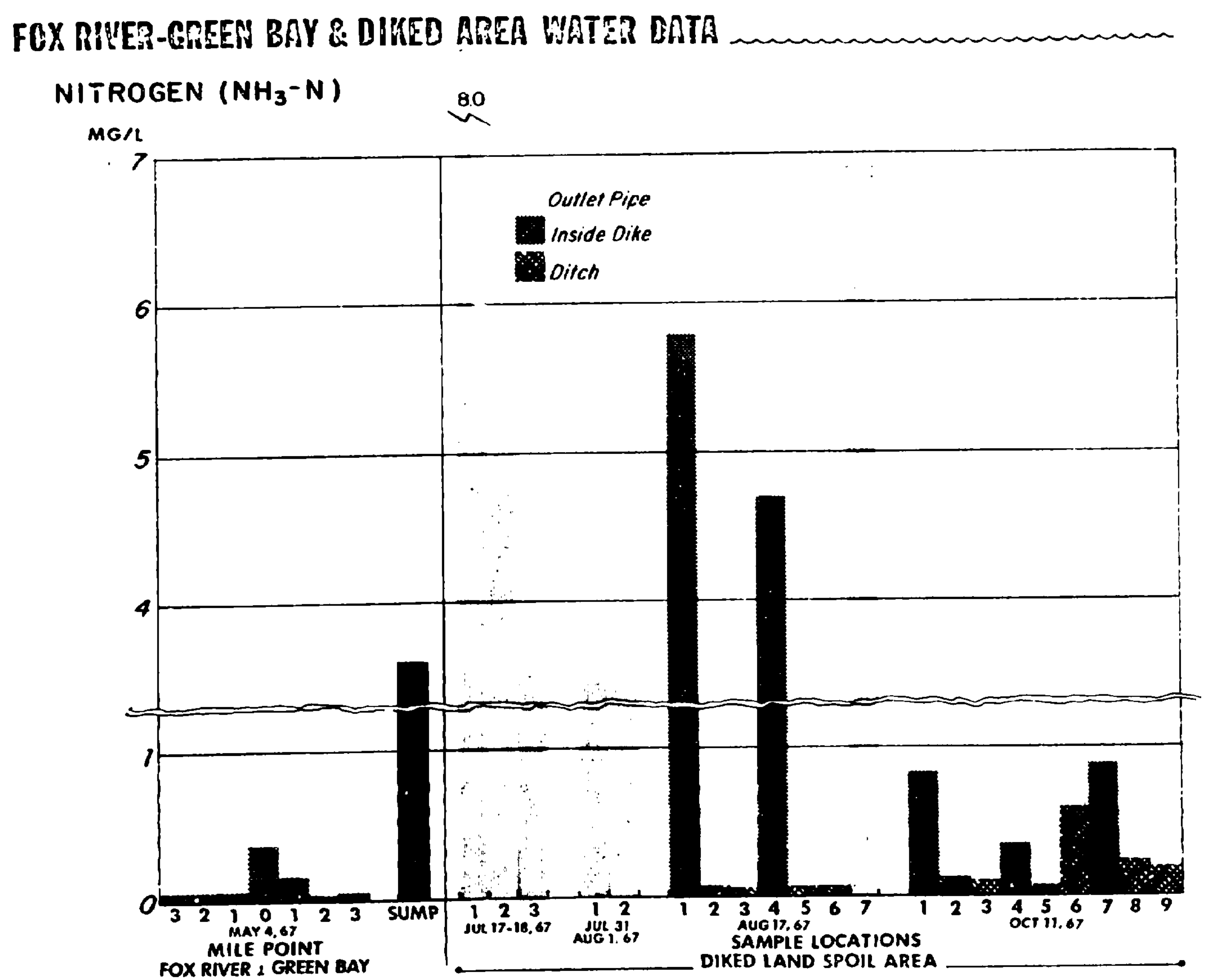

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA
NITROGEN (NH_3-N)
8.0
MG/L
7
6
5
4
1
0
Outlet Pipe
Inside Dike
Ditch
3 2 1 0 1 2 3
MAY 4, 67
MILE POINT
FOX RIVER ↓ GREEN BAY
SUMP
1 2 3
JUL 17-18, 67
1 2
JUL 31
AUG 1, 67
1 2 3 4 5 6 7
AUG 17, 67
1 2 3 4 5 6 7 8 9
OCT 11, 67
SAMPLE LOCATIONS
DIKED LAND SPOIL AREA

FIGURE 15

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA

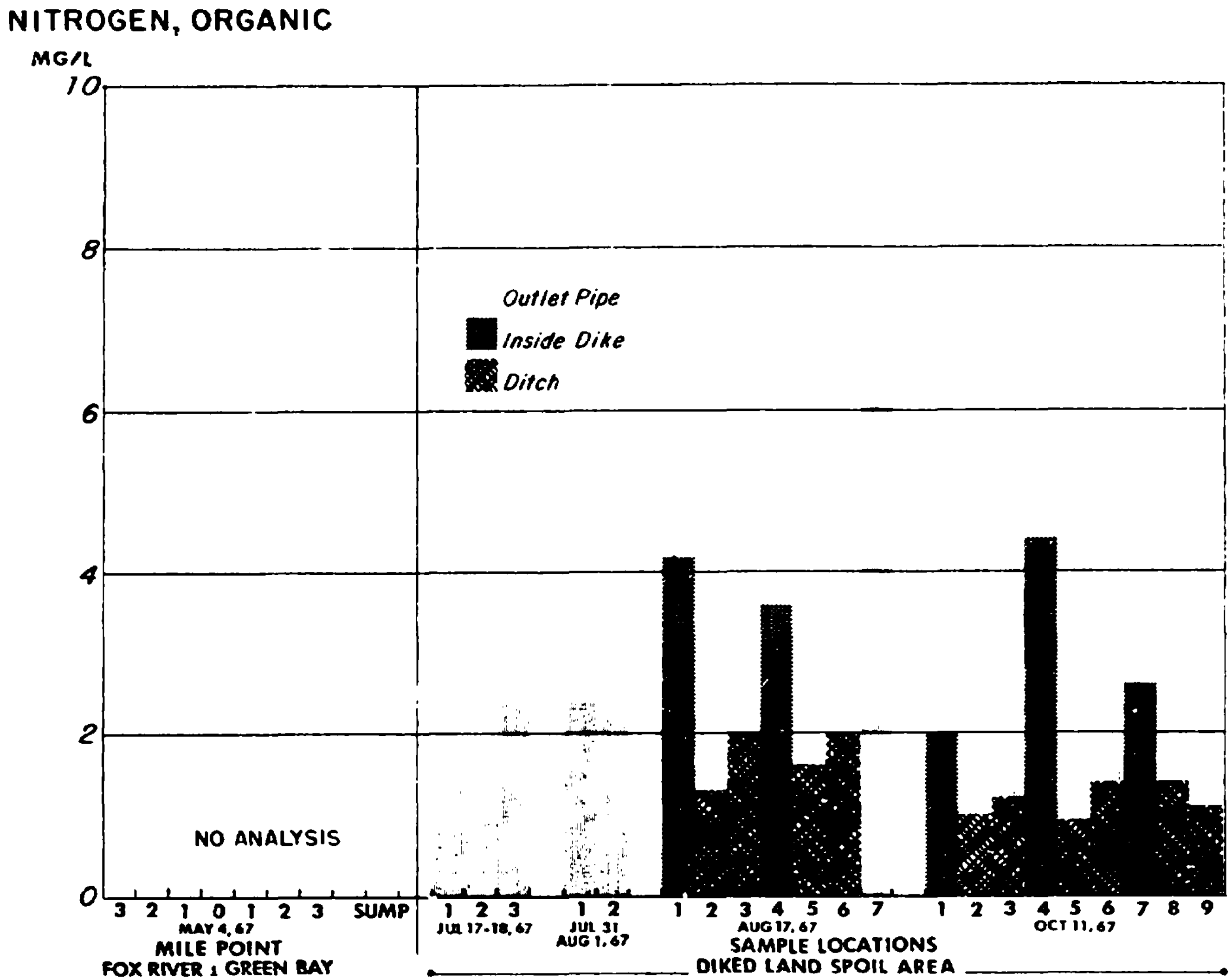


FIGURE 16

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA

DISSOLVED SOLIDS

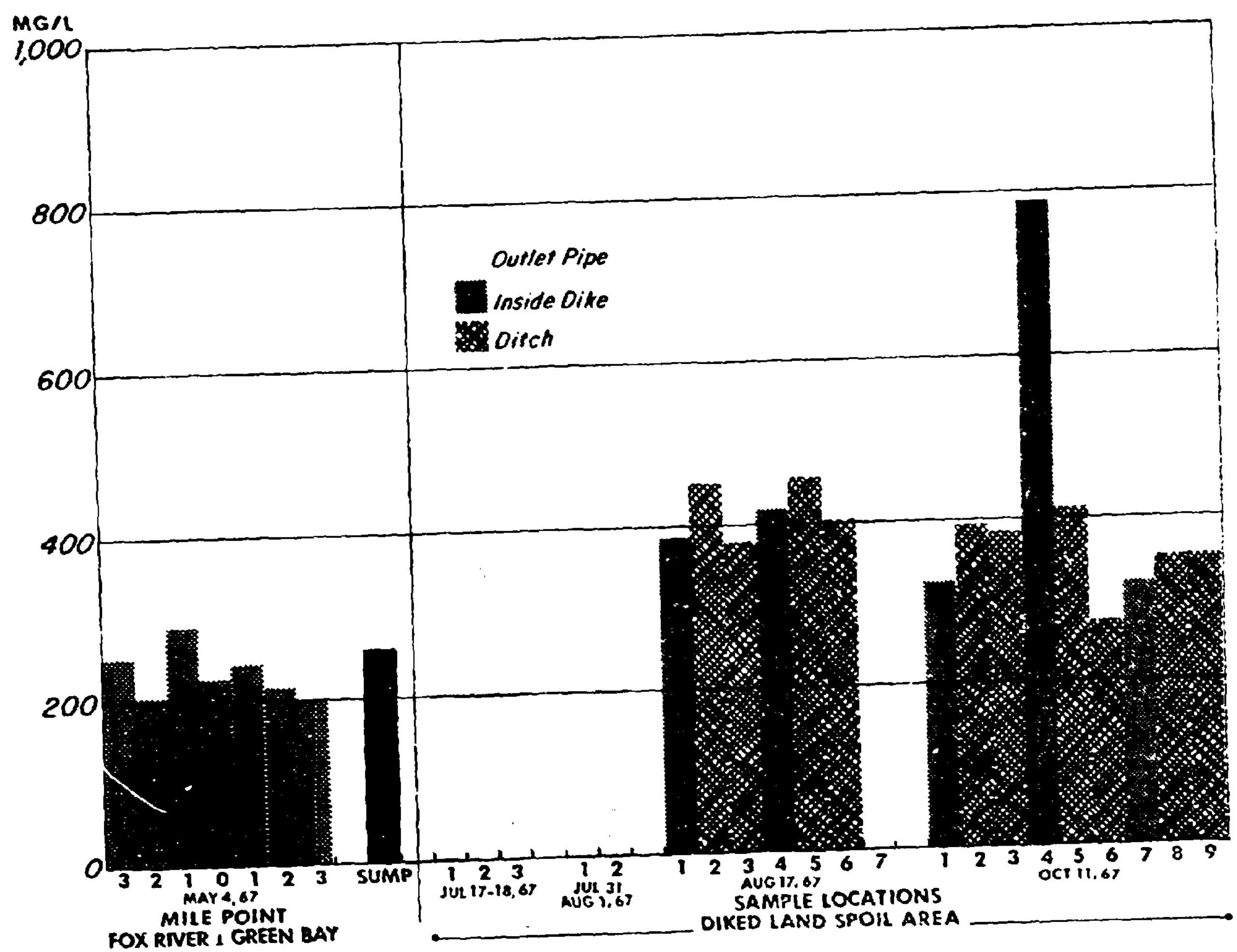


FIGURE 17

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA

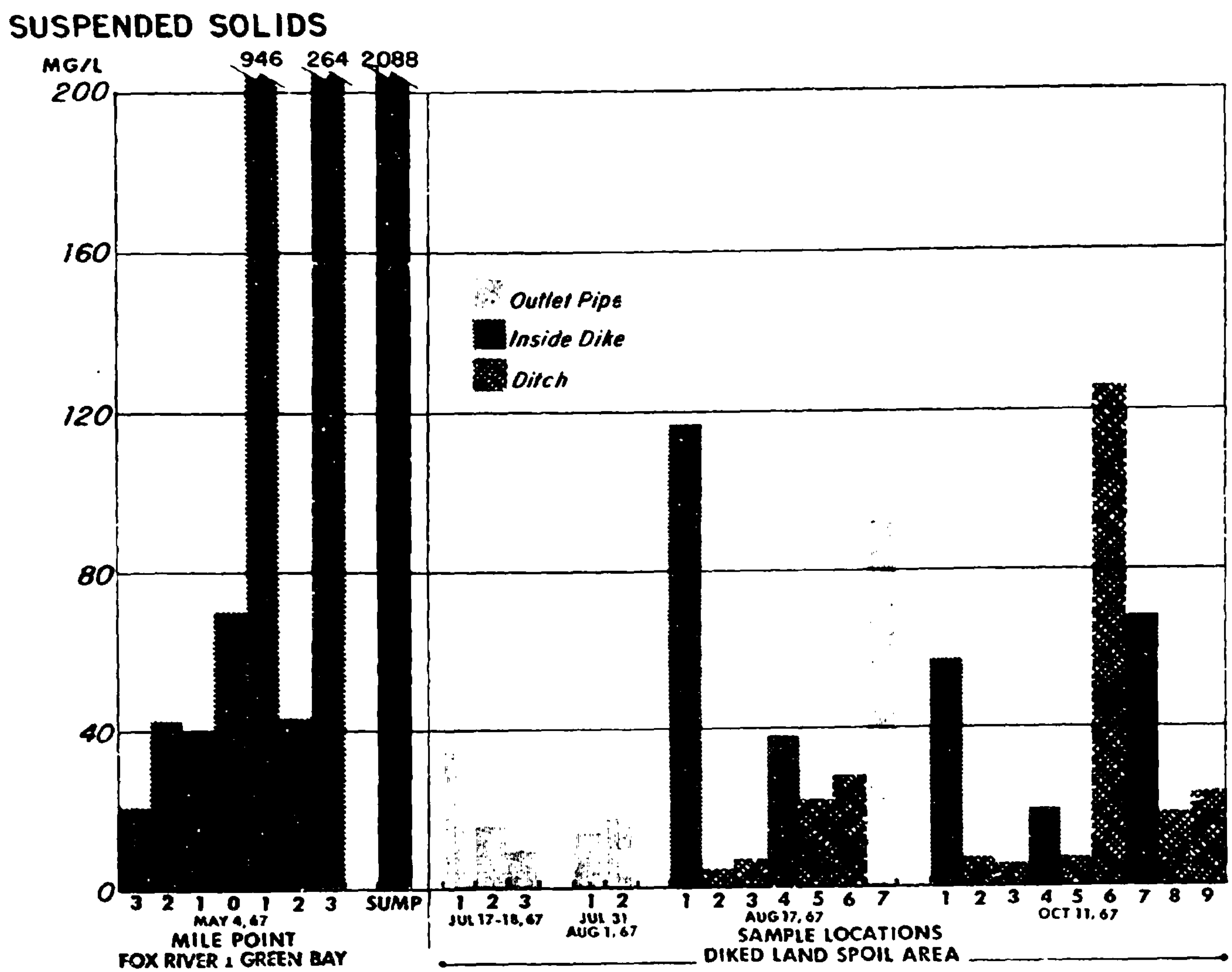


FIGURE 18

FOX RIVER-GREEN BAY & DIKED AREA WATER DATA

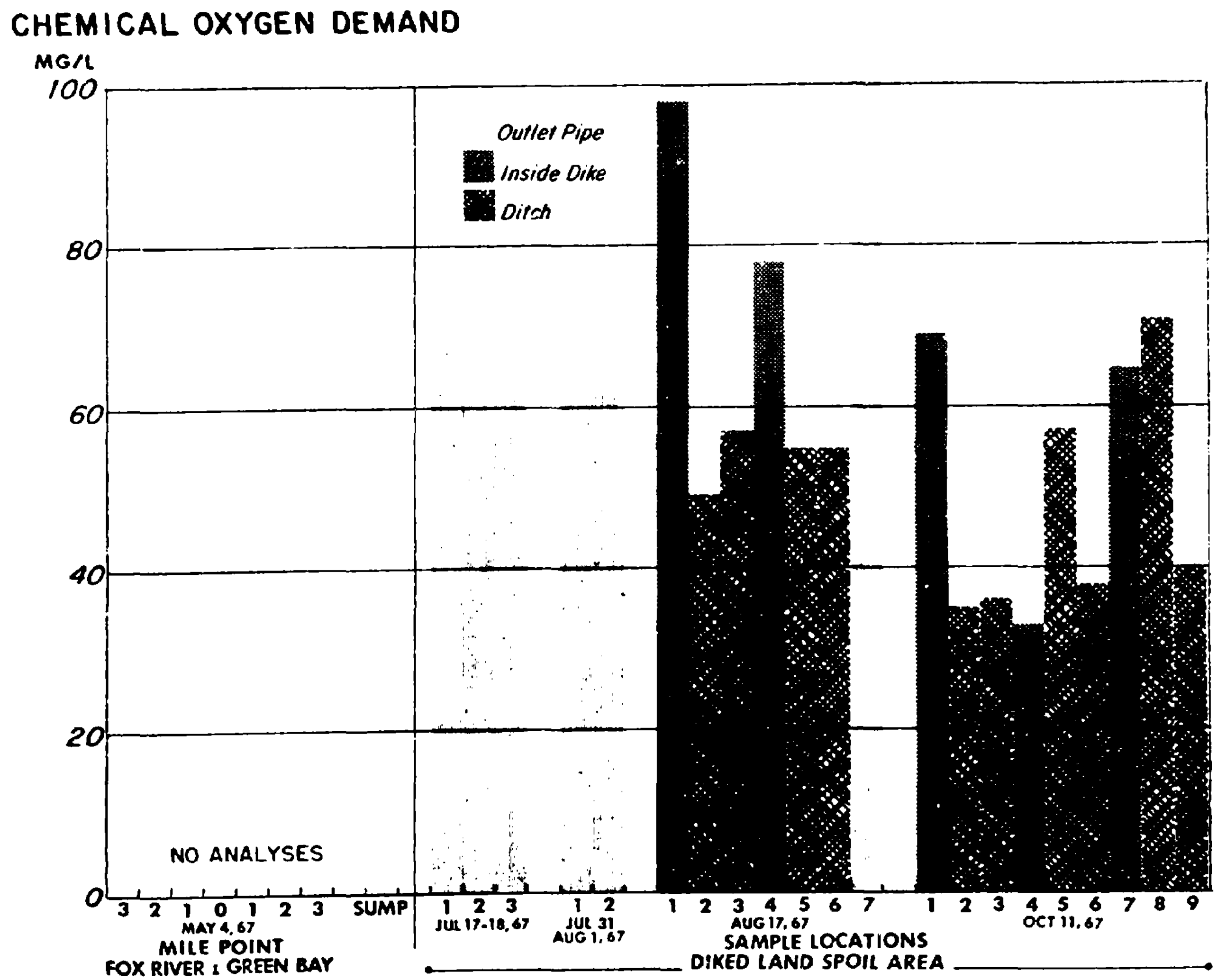


FIGURE 19

ANALYTICAL RESULTS

GREEN BAY BOTTOM SEDIMENT SAMPLES (Continued)

SAMPLING DATE - MAY 4, 1967

Sample No.	Location	Organic Nitrogen mg/k Wet	Organic Nitrogen Dry	C.O.D. mg/k Wet	C.O.D. Dry	Oil and Grease * mg/k Wet	Oil and Grease * Dry	Sulfide mg/k Wet	Sulfide Dry	Phenols µg/g Wet	Phenols Dry	IDOD mg/k Wet	IDOD Dry
1	Fox R. Mile 3	1,030	6,580	46,700	300,000	5,500	35,300	130	830	1.22	7.8	12,800	82,100
2	Fox R. Mile 2	810	6,260	34,600	266,000	6,000	46,200	116	890	0.39	3.0	12,300	94,600
3	Fox R. Mile 1	630	1,480	20,200	47,600	4,800	11,300	134	320	0.14	3.3	9,100	21,400
4	Fox R. Mile 0	920	4,550	52,600	261,000	7,100	35,100	139	690	0.45	2.2	13,500	66,900
5	Green Bay Mile 1	2,080	9,450	54,500	248,000	7,300	33,200	120	550	0.72	3.3	15,300	69,500
6	Green Bay Mile 2	1,230	4,020	66,600	218,000	1,400	4,600	74	240	0.23	0.75	14,800	48,600
7	Green Bay Mile 3	1,220	5,770	37,900	179,000	1,400	6,600	71	330	0.72	3.4	13,800	65,000
8	Sump, Green Bay	970	2,350	50,400	122,000	1,700	4,200	134	320	0.59	1.4	13,900	33,600
9	Scow	1,290	2,490	51,100	117,000	1,900	3,600	328	630	0.22	0.42	16,400	31,400

*Hexane Analysis

Table 1

ANALYTICAL RESULTS

GREEN BAY BOTTOM SEDIMENT SAMPLES

SAMPLING DATE - MAY 4, 1967

Sample No.	Location	Total Solids % of Sample	Vol. Solids % of Total Solids	Total Phosphorus -P mg/k		Soluble Phosphorus-P mg/k		NO_3 - Nitrogen mg/k		NH_3 - Nitrogen mg/k		Total Nitrogen mg/k	
				Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
1	Fox R. Mile 3	15.6	23.7	1,014	6,500	20.5	132.0	2.1	13.5	194	1,240	1,220	7,820
2	Fox R. Mile 2	13.0	21.7	779	5,992	18.0	138.0	2.1	16.2	107	820	920	7,080
3	Fox R. Mile 1	42.5	8.0	691	1,627	9.1	21.5	2.3	5.4	19	50	650	1,530
4	Fox R. Mile 0	20.2	20.0	681	3,374	23.4	116.0	2.1	10.4	81	400	1,000	4,950
5	Green Bay Mile 1	22.0	20.3	903	4,104	24.1	109.5	2.6	11.8	149	680	2,230	10,130
6	Green Bay Mile 2	30.5	17.6	818	2,683	16.3	53.5	3.4	11.1	41	140	1,270	4,160
7	Green Bay Mile 3	21.2	14.8	694	3,276	3.9	18.6	2.1	9.9	127	600	1,350	6,370
8	Sump in Green Bay	41.3	13.4	789	1,910	18.6	45.0	1.8	4.4	143	340	1,110	2,690
9	Scow	52.1	9.5	815	1,565	20.5	39.5	1.5	2.9	346	660	1,640	3,150

(Continued)

ANALYTICAL RESULTS

GREEN BAY WATER SAMPLES

SAMPLING DATE - MAY 4, 1967

Sample No.	Location	Conductivity	Alkalinity mg/l	Turbidity APHA units	Total Phosphorus -P mg/l	Sol. P mg/l	NO_3-Nitrogen mg/l	NH_3-Nitrogen mg/l	Total Nitrogen mg/l	Dissolved Solids mg/l	Suspended Solids mg/l	Chloride mg/l	Sulfate mg/l
1	Fox R. Mile 3	320	112	13.5	0.14	0.09	0.13	0.05	1.4	254	21	16	30
2	Fox R. Mile 2	325	121	11.5	0.22	0.09	0.32	0.05	1.3	204	43	15	32
3	Fox R. Mile 1	310	116	17.0	0.17	0.08	0.44	0.05	1.3	290	40	13	33
4	Fox R. Mile 0	350	113	17.0	0.23	0.07	0.43	0.38	3.1	226	70	19	43
5	Green Bay Mile 1	370	140	300.0	2.41	0.14	0.35	0.17	18.0	244	946	18	34
6	Green Bay Mile 2	330	113	22.0	0.13	0.06	0.22	0.04	1.3	217	53	15	34
7	Green Bay Mile 3	275	107	9.0	.52	0.08	0.13	0.06	1.2	200	264	11	22
8	Sump Green Bay	400	228	740.0	2.41	0.07	0.19	3.60	53.0	260	2,08[illegible]	21	46

Table 2

ANALYTICAL RESULTS

GREEN BAY BOTTOM SEDIMENTS SAMPLES - SUMP AREA (mg/k)

July 17, 1967

Station	% Total Solids	% T. Vol. Solids	NH_3-N		NO_3-N		Org-N		T.Sol.	Phos-phorus-P
			Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
1	27.0	14.8	100	370	1.6	5.9	1085	4020	1.06	3.8
2	27.7	16.7	97	350	2.2	7.9	913	3300	1.66	6.0
3	26.0	18.2	194	745	3.2	12.3	1026	3955	3.11	12.0
4	22.2	17.8	150	675	2.0	9.0	960	4325	2.94	13.4
5	32.6	14.6	117	360	3.6	11.0	1008	3090	2.16	6.5
6	39.3	9.4	131	315	2.0	5.1	959	2465	[illegible].01	5.0
Average	29.1	15.3		469		8.5		3526		7.8

Station	Total Phosphorus-P		COD		Oil & Grease*	
	Wet	Dry	Wet	Dry	Wet	Dry
1	408	1509	48,200	178,500	6,930	25,667
2	301	1088	37,500	135,100	4,270	15,411
3	284	1091	36,000	138,500	2,815	10,827
4	408	1835	37,100	167,000	1,465	6,599
5	301	924	91,600	281,000	6,510	19,963
6	213	541	40,800	104,000	1,835	4,663
Average		1165		167,350		13,855

*Hexane Analysis

Table 3

ANALYTICAL RESULTS

GREEN BAY WATER SAMPLES -- OUTLET PIPE, DIKED LAND SPOIL AREA (mg/l)

Station	Time and Date	Dis. Solids	Susp. Solids	NH_3-N	NO_3-N	Org-N	T. Sol. Phos-phorus-P	Total Phosphorus -P	COD	Turb.*	Phenol**
JULY 17-18, 1967											
1	9:15 a.m. 7/17	328	40	8.0	5.3	1.3	0.12	0.19	67	4.0	
2	3:00 p.m. 7/17	366	16	5.0	6.6	0.9	0.11	0.13	61	2.0	
3	8:00 a.m. 7/18	368	10	3.5	6.5	2.9	0.11	0.13	63	2.0	
JULY 31 - AUGUST 1, 1967											
1	7:00 p.m. 7/31	350	14	3.5	0.92	2.4	0.16	0.20	70	5.0	1
2	8:00 a.m. 8/1	340	18	3.6	0.71	2.2	0.16	0.21	65	3.6	3

* Turbidity expressed in APHA units (equal to Jackson units)
** Phenols expressed in micrograms per liter

Table 4

ANALYTICAL RESULTS

GREEN BAY WATER SAMPLES -- DIKED LAND SPOIL AREA (mg/l)

AUGUST 17, 1967

Sample	Time	NH_3-N	NO_3-N	Org-N	T. Sol. Phos-phorus-P	Total Phosphorus-P	Dis. Solids	Susp. Solids	Turb.*	COD
1 - Dike (Inside)	12:00 N	5.8	2.9	4.2	0.18	0.59	386	117	24.	98
2 - Ditch along Dike	"	0.08	0.30	1.3	0.03	0.04	452	4	1.1	49
3 - Ditch across Road	"	0.06	0.19	1.9	0.04	0.14	378	7	2.5	57
4 - Dike (Inside)	2:00 P.M.	4.7	2.1	3.6	0.12	0.28	420	38	10.	78
5 - Ditch (along Dike)	"	0.07	0.28	1.6	0.02	0.09	458	22	0.6	55
6 - Ditch across Road	"	0.07	0.22	2.0	0.03	0.10	403	28	10.	55
7 - Dike - Outlet Pipe	11:00 A.M.	6.9	1.9	6.1	0.18	0.72	406	92	9.0	107

* APHA Units = Jackson Candle Turbidity Units

Table 5

GREEN BAY

ANALYTICAL RESULTS OF WATER FROM DIKED LAND SPOIL AREA

mg/l

OCTOBER 11, 1967

Type of Sample:	WATER								
Station	1	2	3	4	5	6	7	8	9
Parameter									
T. Sol.-P	0.119	0.037	0.039	0.086	0.044	0.414	0.123	0.040	0.032
Total-P	0.252	0.074	0.063	0.224	0.109	0.629	0.273	0.105	0.119
NH_3-N	0.84	0.12	0.10	0.36	0.07	0.59	0.90	0.23	0.20
NO_3-N	0.61	0.03	0.02	-	0.03	0.11	0.36	0.06	0.06
Org-N	2.0	1.0	1.2	4.4	0.91	1.4	2.6	1.4	1.1
Sus. Solids	57	7	5	19	7	126	68	18	24
Dis. Solids	327	393	385	789	415	274	324	353	354
Turbidity	27	1.4	4.0	4.5	0.7	9.0	14	12	7.7
COD	69	35	36	33	57	38	65	71	40

Table 6

APPENDIX A 10

REPORT ON THE DEGREE OF POLLUTION OF BOTTOM
SEDIMENTS IN NEW BUFFALO HARBOR, MICHIGAN
JUNE 4, 1968

JUNE 1968

Federal Water Pollution Control Administration
Great Lakes Region
Chicago Program Office

In accordance with an agreement between the Federal Water Pollution Control Administration and the United States Army Corps of Engineers that the Federal Water Pollution Control Administration would determine the degree of pollution of bottom sediments in harbors to be dredged by the Corps of Engineers, personnel of the Chicago Program Office sampled New Buffalo Harbor, Michigan on June 4, 1968. The points sampled represent areas scheduled for dredging on a map provided by the Corps of Engineers.

Members of the sampling crew were:

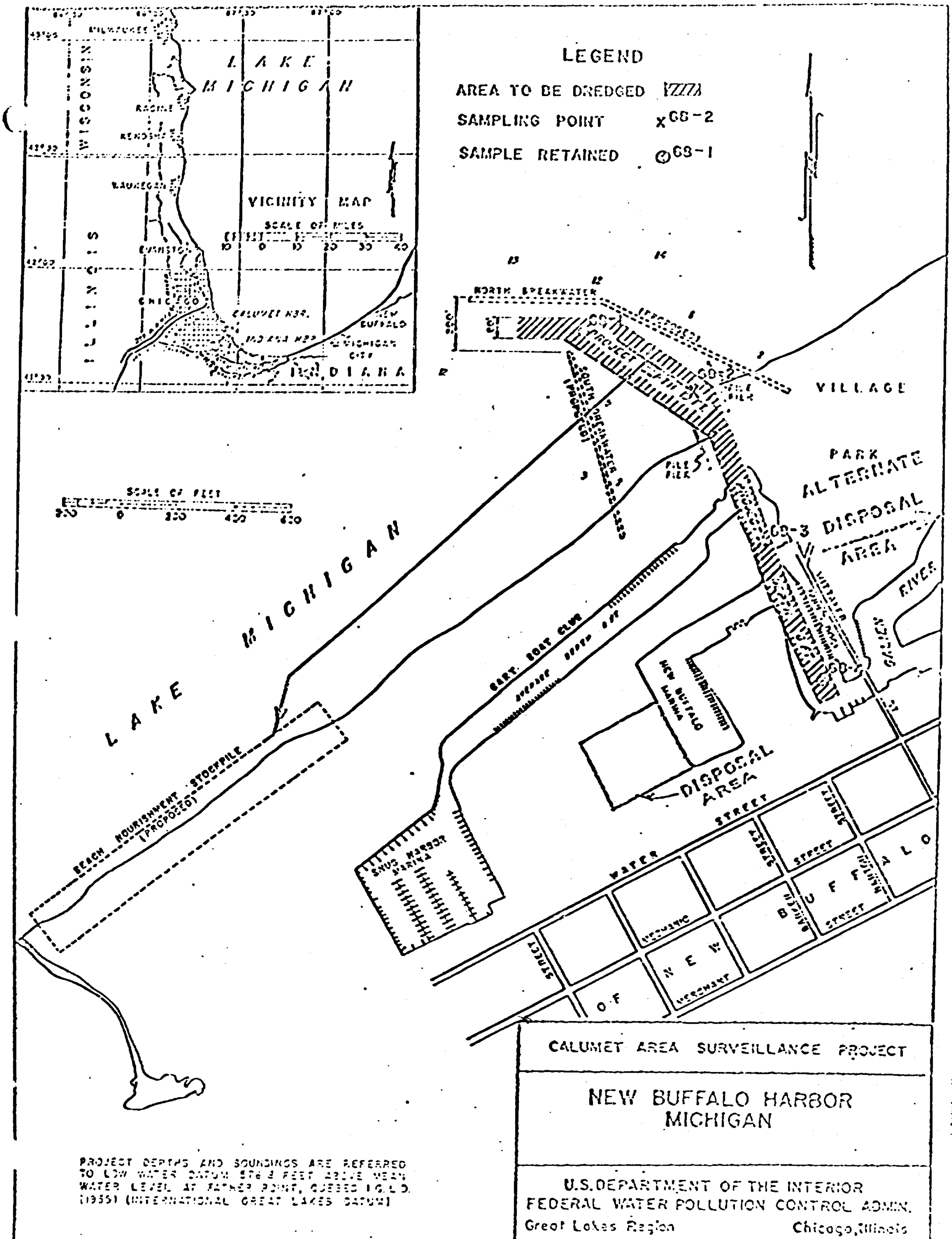
Robert J. Bowden - Sanitary Engineer
Joseph V. Slovick - Hydraulic Technician
Daniel Chorowicki - Boat Operator-Sampler

CONCLUSIONS

1. The bottom sediments outside of the mouth of the Galien River consist of sand substantially free from pollution.

2. The bottom sediments in the Galien River in the area scheduled for dredging are slightly to moderately polluted.

3. The quality of the water entering Lake Michigan from the Galien River was good and the river did not constitute a serious source of pollution to the lake.


LEGEND
AREA TO BE DREDGED
SAMPLING POINT
SAMPLE RETAINED
LAKE MICHIGAN
VICINITY MAP
SCALE OF MILES
WISCONSIN
ILLINOIS
INDIANA
MILWAUKEE
RACINE
KENOSHA
WAUKEGAN
EVANSTON
CHICAGO
CALUMET HBR.
INDIANA HBR.
NEW BUFFALO
MICHIGAN CITY
SCALE OF FEET
NORTH BREAKWATER
VILLAGE
PARK
ALTERNATE DISPOSAL AREA
RIVER
NEW BUFFALO MARINA
DISPOSAL AREA
WATER STREET
SNUG HARBOR MARINA
BEACH NOURISHMENT STOCKPILE (PROPOSED)
LAKE MICHIGAN
VILLAGE OF NEW BUFFALO
CALUMET AREA SURVEILLANCE PROJECT
NEW BUFFALO HARBOR
MICHIGAN
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois
PROJECT DEPTHS AND SOUNDINGS ARE REFERRED TO LOW WATER DATUM 576.8 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC I.G.L.D. (1955) (INTERNATIONAL GREAT LAKES DATUM)

DISCUSSION OF RESULTS

The field observations of the sediment samples indicated an unpolluted sandy bottom in the outer harbor at Stations NBUF 68-1 and NBUF 68-2 and a darker sand with some pollution further up the Galien River at Stations NBUF 68-3 and NBUF 68-4 (see Table I). The river itself appeared to be substantially free of pollution. Fish were observed jumping in the river and a pair of ducks were swimming on it near Station NBUF 68-4.

The chemical analyses confirm these observations. The sand at Station NBUF 68-1 had low concentrations of COD, Total Phosphorus and sulfide. The percent volatile solids was also very low. There was a trace of cyanide and some oil and grease (see Table II). These concentrations were far lower than at other harbors on the lake. At Station NBUF 68-4 there was a moderate amount of cyanide and oil and grease. Phosphorus approached a moderate level but COD, percent volatile solids, sulfide were all low.

The water quality at the mouth of the Galien River (Station NBUF 68-2) meets the criteria established by the Calumet Area Conferees for inner harbor basins (see Table III). It is recognized that these criteria cannot be officially applied at New Buffalo harbor and they are used only for comparison and evaluation purposes.

Color photographs were taken of all of the bottom samples observed. These are on file at the Chicago Program Office of the Federal Water Pollution Control Administration.

TABLE I

FIELD OBSERVATIONS
NEW BUFFALO HARBOR

JUNE 4, 1968

Station NBUF 68-1	Depth 10' Clean sand, various color stones, no odor sample retained.
Station NBUF 68-2	Depth 5' Sandy gravel, flat stones, about 1" square 1/2" thick, no odor.
Station NBUF 68-3	Depth 9' Grey sand, no odor - clam shells, one sludgeworm
Station NBUF 68-4	Depth 8' Dark grey silty sand, little odor decayed wood, few sludge worms

TABLE II

RESULTS OF ANALYSIS OF BOTTOM SEDIMENTS
COLLECTED AT NEW BUFFALO HARBOR, JUNE 4, 1968

Parameter	Station NBUF 68-1	Station NBUF 68-4
% Total Solids	85.34	69.24
% Volatile Solids	1.18	2.86
COD	8402 mg/kg	33,128 mg/kg
Total Phosphorus	9.76 mg/kg	90.2 mg/kg
NH_3-N	-	23.1 mg/kg
NO_3-N	5.4 mg/kg	4.6 mg/kg
Org. N	-	2068 mg/kg
Phenol	NF	0.46 mg/kg
Oil & Grease	521 mg/kg	1206
Cyanide	0.01 mg/kg	0.16 mg/kg
Sulfide	NF	16 mg/kg
Total Iron	4718 mg/kg	6990 mg/kg
Copper	3.2 mg/kg	4.6 mg/kg
Cadmium	0.38 mg/kg	0.10 mg/kg
Nickel	8.3 mg/kg	23 mg/kg
Zinc	-	27 mg/kg
Lead	9.4 mg/kg	16 mg/kg
Chromium	9.4 mg/kg	17 mg/kg

All results reported on DRY basis.

NF - None found

TABLE III

RESULTS OF ANALYSIS OF WATER SAMPLES
COLLECTED IN NEW BUFFALO HARBOR June 4, 1968

Station NBUF 68-2

Parameter	
Temp °C	16
pH	9.1
Suspended Solids	4 mg/l
Dissolved Solids	225 "
Turbidity	0.03 units *
MBAS	0.03 mg/l
Chloride	7.5 "
Sulfate	25 "
COD	7.8 "
Total Phosphorus	0.004 "
NH_3-N	0.07 "
NO_2+NO_3-N	0.15 "
Org. N	0.35 "
Phenol	5 µg/l
Oil and Grease	2.5 mg/l
Cyanide	NF "
Total Iron	0.56 "
Copper	0.07 "
Cadmium	NF "
Nickel	0.08 "
Zinc	0.06 "
Lead	0.01 "
Chromium	0.02 "

* Turbidity is expressed in APHA units, equivalent to Jackson units.

NF - Not detected within sensitivity of test.

LOCATION OF SAMPLING POINTS
NEW BUFFALO HARBOR

June 4, 1968

NBUF 68-1	425 feet northwest of end of south pile pier.
NBUF 68-2	Mid-channel at outer end of south pile pier.
NBUF 68-3	Mid-channel 150' upstream of Snug Harbor Marina entrance.
NBUF 68-4	Mid-channel 375' upstream of entrance to New Buffalo Marina.

APPENDIX A 11

REPORT ON THE DEGREE OF POLLUTION OF BOTTOM
SEDIMENTS IN OCONTO HARBOR
May 22, 1968

July, 1968

Federal Water Pollution Control Administration
Great Lakes Region
Chicago Program Office

In accordance with an agreement between the Federal Water Pollution Control Administration and the United States Army Corps of Engineers that the Federal Water Pollution Control Administration would determine the degree of pollution of bottom sediments in harbors to be dredged by the Corps of Engineers, personnel of the Chicago Program Office sampled Oconto Harbor on May 22, 1968. The points sampled represent areas scheduled for dredging on a map provided by the Corps of Engineers.

Members of the sampling crew were:

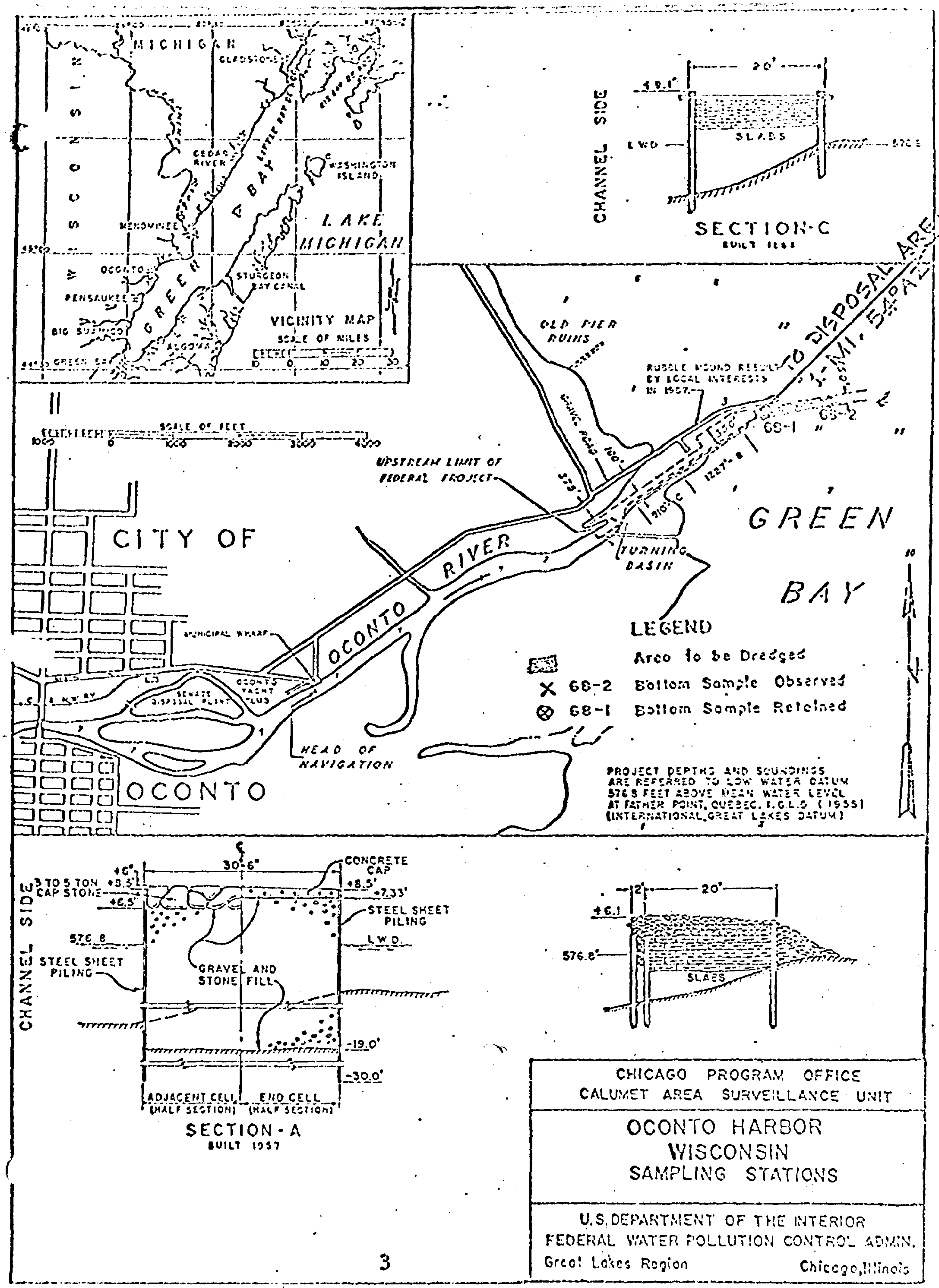
Robert J. Bowden - Sanitary Engineer
Joseph V. Slovick - Hydraulic Technician
Daniel Chorowicki - Boat Operator - Sampler

CONCLUSIONS

1. The sediments in the area to be dredged at the mouth of the Oconto River consist primarily of sand and are relatively unpolluted.

2. The disposal of the material in the open waters of Green Bay would not constitute a serious source of phosphorus or other pollutants to Lake Michigan.

3. The water entering Green Bay from the Oconto River on May 22, 1968 substantially met reasonable criteria and did not constitute a serious source of pollution to Green Bay.



MICHIGAN
GLADSTONE
WISCONSIN
CEDAR RIVER
WASHINGTON ISLAND
LITTLE BAY DE NOC
MENOMINEE
GREEN BAY
LAKE MICHIGAN
OCONTO
STURGEON BAY CANAL
PENSAUKEE
BIG SUAMICO
ALGOMA
VICINITY MAP
SCALE OF MILES
CHANNEL SIDE
20'
L.W.D.
SLABS
576.8
SECTION-C
SCALE OF FEET
OLD PIER RUINS
RUBBLE MOUND REBUILT BY LOCAL INTERESTS IN 1957
TO DISPOSAL AREA
68-1
68-2
UPSTREAM LIMIT OF FEDERAL PROJECT
CITY OF OCONTO
OCONTO RIVER
TURNING BASIN
GREEN BAY
MUNICIPAL WHARF
SEWAGE DISPOSAL PLANT
OCONTO YACHT CLUB
HEAD OF NAVIGATION
LEGEND
Area to be Dredged
68-2 Bottom Sample Observed
68-1 Bottom Sample Retained
PROJECT DEPTHS AND SOUNDINGS ARE REFERRED TO LOW WATER DATUM 576.8 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC. I.G.L.D. (1955) (INTERNATIONAL GREAT LAKES DATUM)
30'-6"
CONCRETE CAP
3 TO 5 TON CAP STONE
+8.5'
+7.33'
+6.5'
STEEL SHEET PILING
576.8
L.W.D.
GRAVEL AND STONE FILL
-19.0'
-30.0'
ADJACENT CELL (HALF SECTION)
END CELL (HALF SECTION)
SECTION-A
BUILT 1957
+6.1
576.8'
20'
SLABS
CHICAGO PROGRAM OFFICE
CALUMET AREA SURVEILLANCE UNIT
OCONTO HARBOR
WISCONSIN
SAMPLING STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois

DISCUSSION OF RESULTS

The field observations indicated that the sediments in the area to be dredged consist primarily of sand and are very lightly polluted, if at all. Charcoal and wood chips at Sta. OCON 68-1 indicated the possible presence of organic material but the sediment was very sandy and did not appear to be seriously polluted. Several fish were caught by fishermen in the Oconto River while the samples were being collected (see Table I). The water also appeared to be free of pollution, it was clear and had no floating algae or solids. It had a very dark brown color, however.

Color photographs were taken of each bottom sample observed and are on file at the Chicago Program Office of the Federal Water Pollution Control Administration.

The results of the analysis verify the field observations. Except for traces of copper and chromium concentration all of the parameters were low in comparison with sediments from other Lake Michigan harbors (see Table II).

Sediments from Station OCON 68-1 were analyzed. This is presumed to be the most polluted area scheduled for dredging. Percent volatile solids was very low at this point and no oil and grease or sulfide were found within the sensitivity of the tests. All of the other parameters were within the range that indicates relatively slight pollution.

The disposal of this material in the open waters of Green Bay would not constitute a significant source of phosphorus or other pollutants to Lake Michigan.

The quality of the water discharging from the Oconto River to Green Bay was also checked. The water substantially met the criteria adopted by the

Calumet Area Conferees for inner harbor basins (see Table III). It is recognized that these criteria cannot be officially applied to Oconto Harbor, they are used herein for comparison and evaluation purposes only. Table III shows that all the criteria were complied with except for phenols and ammonia nitrogen.

TABLE I

FIELD OBSERVATIONS OF BOTTOM SEDIMENTS
OCONTO HARBOR
May 22, 1968

Sta. OCON 68-1	Depth 10' Sand; black specks - some charcoal or wood chips - no odor
Sta. OCON 68-2	Depth 16' Dark brown sand - black specks - no odor

TABLE II

RESULTS OF ANALYSIS OF BOTTOM SEDIMENTS
COLLECTED AT OCONTO HARBOR May 22, 1968

Parameter	Station OCON 68-1
% Total Solids	78.37%
% Volatile Solids	0.91%
COD	11,432 mg/kg
Total Phosphorus	79.7 mg/kg
NO_3-N	5.1 mg/kg
Phenol	0.24 mg/kg
Oil and Grease	NF
Cyanide	0.05 mg/kg
Sulfide	NF
Total Iron	1582 mg/kg
Copper	13 mg/kg
Cadmium	NF
Nickel	7.0 mg/kg
Zinc	29 mg/kg
Lead	3.8 mg/kg
Chromium	11 mg/kg

All results reported on DRY basis.

NF- None found within sensitivity of test.

TABLE III

RESULTS OF ANALYSIS OF WATER SAMPLES
COLLECTED AT OCONTO HARBOR, May 22, 1968

Station OCON 68-1

Parameter		Criteria
Temp. °C	14	not more than 29.6
pH	8.0	within range 7.5-9.0
Suspended Solids	3 mg/l	
Dissolved Solids	19 mg/l	not more than 230 mg/l
Turbidity	0.5 units*	
MBAS	0.09 mg/l	not more than 0.30 mg/l
Chloride	6.0 mg/l	not more than 30 mg/l
Sulfate	12 mg/l	not more than 75 mg/l
COD	56 mg/l	
Total Phosphorus	0.025 mg/l	not more than 0.033 mg/l
NH_3-N	0.32 mg/l	not more than 0.12 mg/l
NO_2-NO_3-N	0.08 mg/l	
Org. N	0.83 mg/l	
Phenol	9 µg/l	not more than 5 µg/l
Oil and Grease	4.5 mg/l	
Cyanide	NF	not more than 0.1 mg/l
Total Iron	0.60 mg/l	
Copper	0.32 mg/l	
Cadmium	NF	
Nickel	0.08 mg/l	
Zinc	0.07 mg/l	
Lead	0.03 mg/l	
Chromium	0.02 mg/l	

*Turbidity is expressed in APHA units, equivalent to Jackson units.
NF - not detected within sensitivity of test.

LOCATION OF SAMPLING POINTS
OCONTO HARBOR, May 22, 1968

Sta.	OCON 68-1	100 feet south of North Pierhead Light. Lat. 44°-53'-57" Long. 87°-49'-16"
Sta.	OCON 68-2	900 feet east of North Pierhead Light. Lat. 44°-53'-58" Long. 87°-49'-05"

APPENDIX A 12

REPORT ON THE DEGREE OF POLLUTION OF BOTTOM
SEDIMENTS IN PENSAUKEE HARBOR
May 21, 1968

JULY 1968

Federal Water Pollution Control Administration
Great Lakes Region
Chicago Program Office

In accordance with an agreement between the Federal Water Pollution Control Administration and the United States Army Corps of Engineers that the Federal Water Pollution Control Administration would determine the degree of pollution of bottom sediments in harbors to be dredged by the Corps of Engineers, personnel of the Chicago Program Office sampled Pensaukee Harbor on May 21, 1968. The points sampled represent areas scheduled for dredging on a map provided by the Corps of Engineers.

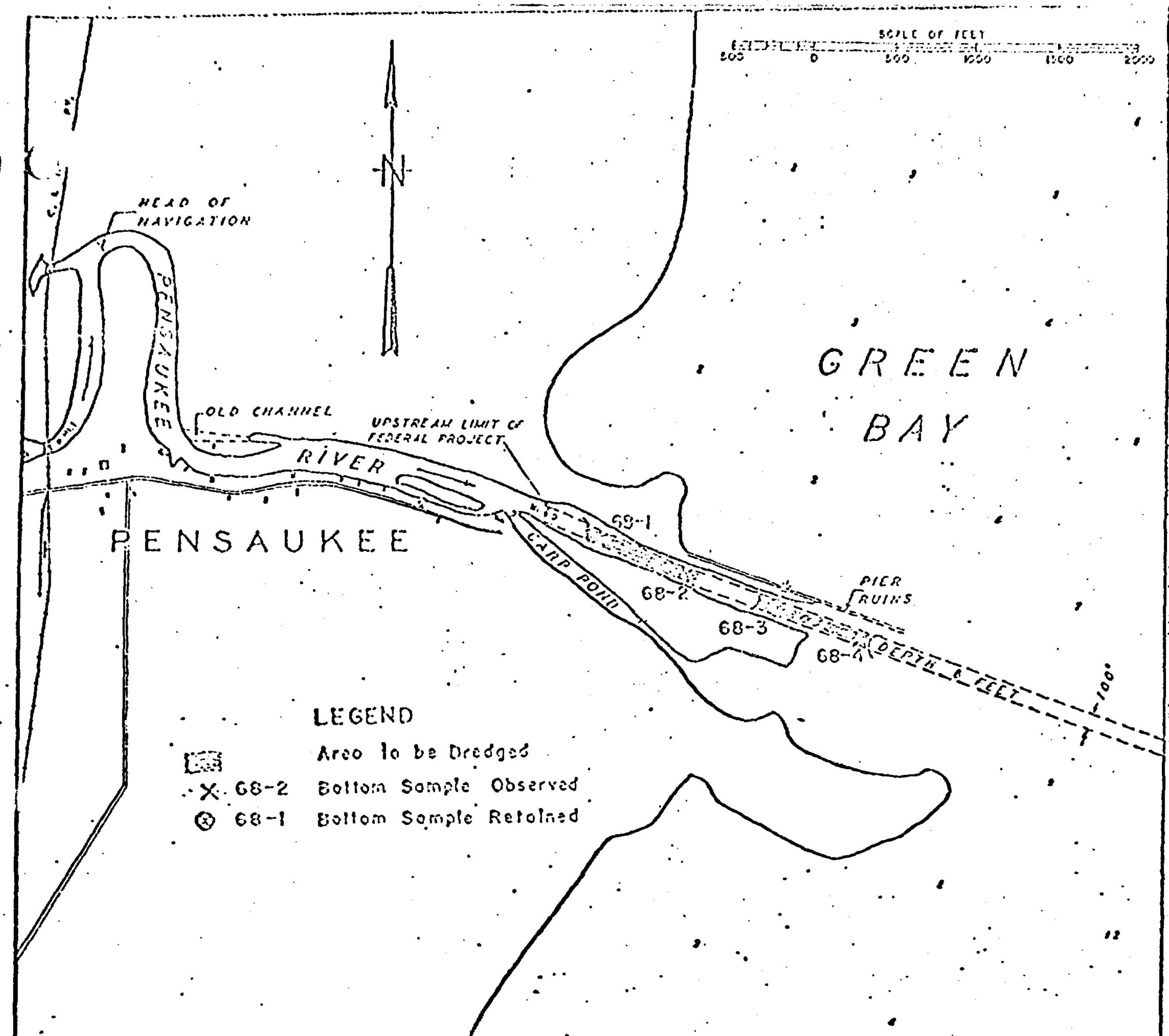
Members of the sampling crew were:

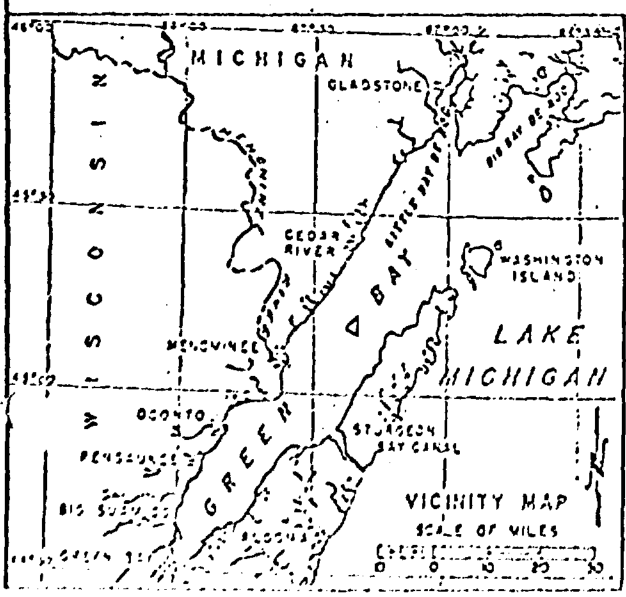
Robert J. Bowden - Sanitary Engineer
Joseph V. Slovick - Hydraulic Technician
Daniel Chorowicki - Boat Operator - Sampler

CONCLUSIONS

1. The bottom sediments to be dredged at Pensaukee Harbor consist primarily of sand with some silt. They are not seriously polluted but have a moderately high concentration of total phosphorus.

2. The waters entering Green Bay from the Pensaukee River substantially met reasonable water quality criteria on May 21, 1968 and did not constitute a major source of pollution to Lake Michigan.





CHICAGO PROGRAM OFFICE
CALUMET AREA SURVEILLANCE UNIT

PENSAUKEE HARBOR
WISCONSIN
SAMPLING STATIONS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region Chicago, Illinois

DISCUSSION OF RESULTS

The field observations indicate that the bottom sediment in the areas scheduled for dredging at Pensaukee Harbor consist of a dark brown sand with some silt and that they may be moderately polluted but are not heavily polluted (see Table I). The clamshells at Stations PEHS 68-1 and PEHS 68-2 could be from pollution tolerant or pollution sensitive species. In any case they are evidence that the bottom sediments are not as seriously polluted as at some other harbors on Lake Michigan. At Station PEHS 68-2 a four-inch bullhead was caught inside of the dredge. It was released unharmed. Fishermen caught several other fish while sampling was in progress. Station PEHS 68-3 appeared to be the most polluted of the four points observed. A sample from this point was retained for analysis. At Station PEHS 68-4 the bottom consisted of clean sand.

Color photographs were taken of the samples observed at each station. These photographs are on file at the Chicago Program Office of the Federal Water Pollution Control Administration.

The results of the analyses confirmed the field observations. These were moderate concentrations of total phosphorus and ammonia nitrogen, traces of copper and chromium and a high concentration of sulfide. Lower concentrations of COD, organic nitrogen, phenol, oil and grease and total iron were found. No cyanide was found within the sensitivity of the test. These results indicate some pollution from domestic sources but no industrial pollution.

The water quality at the mouth of the Pensaukee River substantially met the criteria adopted by the Calumet Area Enforcement Conferees for inner harbor basins. It is recognized that these criteria cannot be officially applied at

Pensaukee Harbor and they are used therein for comparison and evaluation purposes only. Table III shows that all of the criteria were met except for dissolved solids and phenols. On May 21, 1968 the waters discharging to Green Bay from the Pensaukee River did not constitute a major source of pollution.

TABLE I

FIELD OBSERVATIONS

PENSAUKEN HARBOR
May 21, 1968

Sta. PENS 68-1	Depth 6' Dark brown silty sand; clamshells, fishy odor.
Sta. PENS 68-2	Depth 7' Dark brown silty sand; clamshells, fishy odor; 4" bullhead caught in dredge, we released it alive.
Sta. PENS 68-3	Depth 7' Grey-black sand; a few sludgeworms; no odor sample retained.
Sta. PENS 68-4	Depth 4' Clean sand; few sludgeworms; no odor.

TABLE II

RESULTS OF ANALYSIS OF BOTTOM SEDIMENTS
COLLECTED AT PENSAUKEN HARBOR, May 21, 1968

Parameter	Station PENS 68-3	
% Total Solids	64.57	
% Volatile Solids	3.00	
COD	32,751	mg/kg
Total Phosphorus	258	mg/kg
NH_3-N	59.5	mg/kg
NO_3-N	5.0	mg/kg
Org. N	1155	mg/kg
Phenol	0.79	mg/kg
Oil & Grease	976	mg/kg
Cyanide	NF	
Sulfide	105	mg/kg
Total Iron	4585	mg/kg
Copper	24	mg/kg
Cadmium	.80	mg/kg
Nickel	22	mg/kg
Zinc	15	mg/kg
Lead	11	mg/kg
Chromium	20	mg/kg

All results reported on DRY basis.

NF - None found within sensitivity of test.

TABLE III

RESULTS OF ANALYSIS OF WATER SAMPLES COLLECTED AT PENSAUKEN HARBOR, May 21, 1968

Station PENS 68-3

Parameter		Criteria
Temperature °C	15	not more than 29.6
pH	8.6	within range 7.5-9.0
Suspended Solids	3 mg/l	
Dissolved Solids	313 mg/l	not more than 230 mg/l
Turbidity	1.5 units*	
MBAS	0.10 mg/l	not more than 0.30 mg/l
Chloride	7.5 mg/l	not more than 30 mg/l
Sulfate	33 mg/l	not more than 75 mg/l
COD	52 mg/l	
Total Phosphorus	0.017 mg/l	not more than 0.033 mg/l
NH_3-N	0.09 mg/l	not more than 0.12 mg/l
NO_2+NO_3-N	0.01 mg/l	
Org. N	1.00 mg/l	
Phenol	9 ug/l	not more than 5 ug/l
Oil and Grease	2.9 mg/l	
Cyanide	NF	not more than 0.1 mg/l
Total Iron	0.71 mg/l	
Copper	0.16 mg/l	
Cadmium	NF	
Nickel	0.06 mg/l	
Zinc	0.05 mg/l	
Lead	0.01 mg/l	
Chromium	0.02 mg/l	

*Turbidity is expressed in APHA units, equivalent to Jackson units.
NF - not detected within sensitivity of test.

APPENDIX A 13

REPORT ON THE DEGREE OF POLLUTION OF BOTTOM
SEDIMENTS IN FOX RIVER
May 21, 1968

July 1968

Federal Water Pollution Control Administration
Great Lakes Region
Chicago Program Office

In accordance with an agreement between the Federal Water Pollution Control Administration and the United States Army Corps of Engineers that the Federal Water Pollution Control Administration would determine the degree of pollution of bottom sediments in harbors to be dredged by the Corps of Engineers, personnel of the Chicago Program Office sampled Fox River on May 21, 1968. The points sampled represent areas scheduled for dredging on a map provided by the Corps of Engineers.

Members of the sampling crew were:

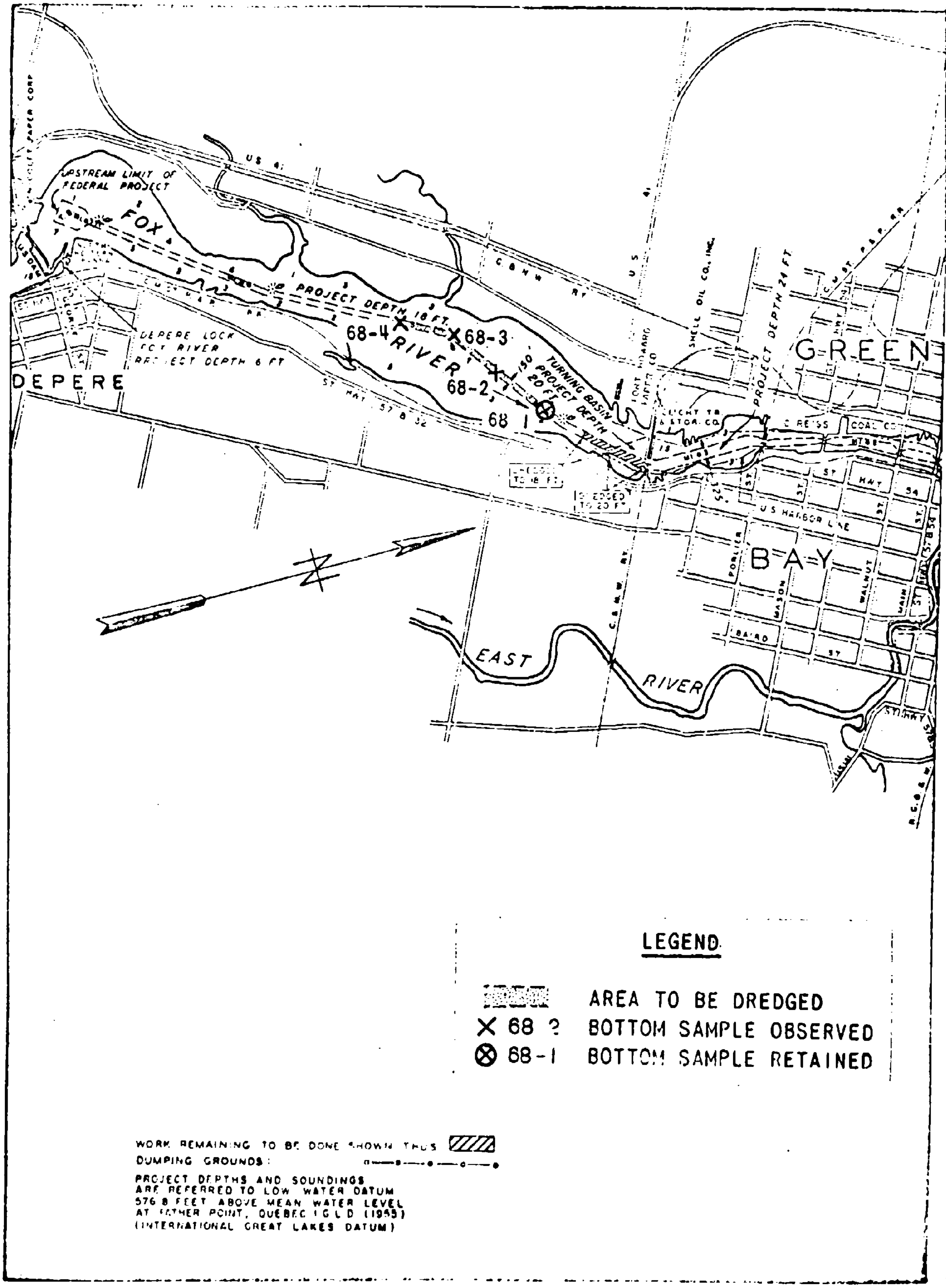
Robert J. Bowden - Sanitary Engineer
Joseph V. Slovick - Hydraulic Technician
Daniel Chorowicki - Boat Operator - Sampler

CONCLUSIONS

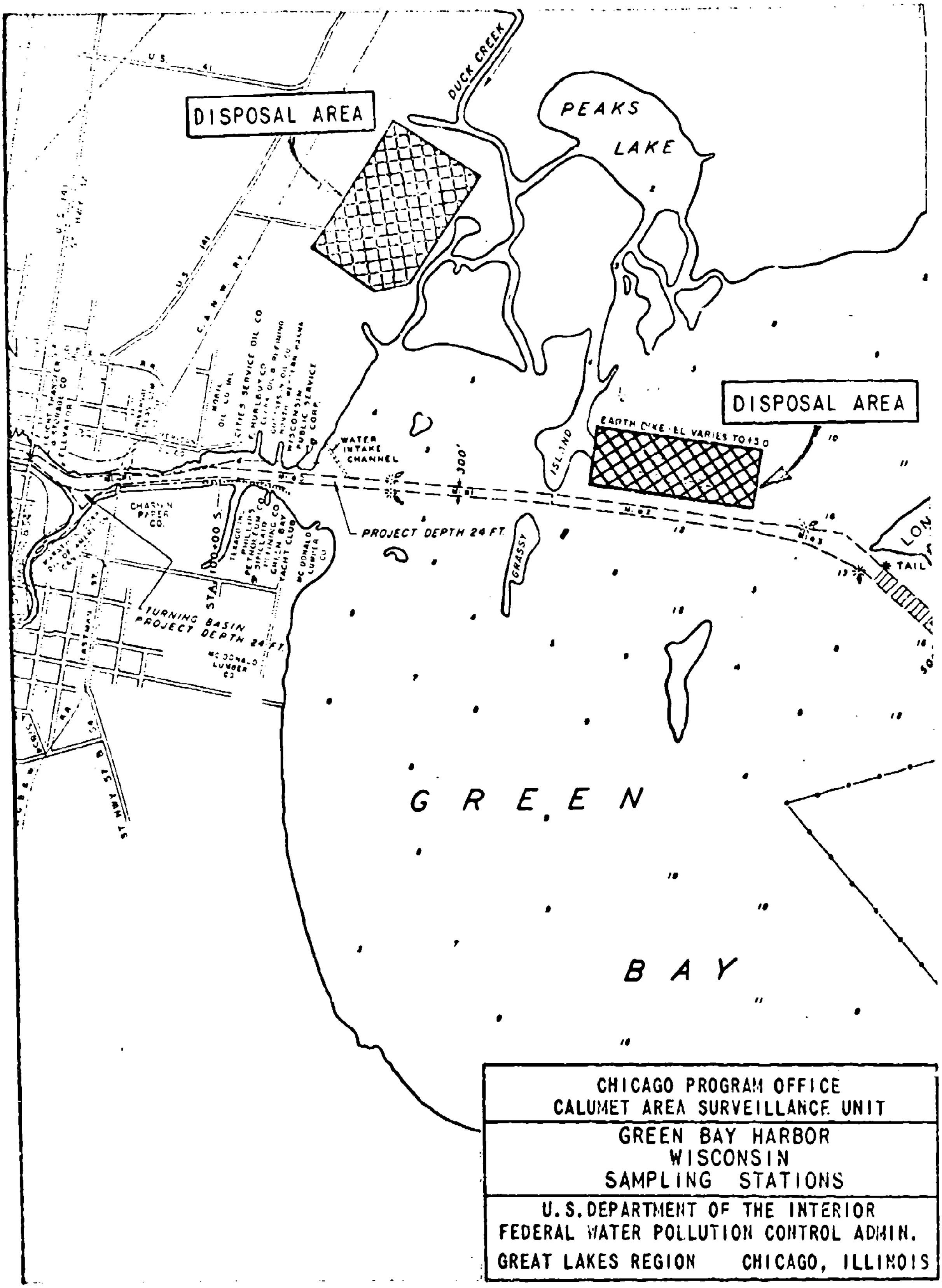
1. The bottom sediments in the area to be dredged in the Fox River are very heavily polluted.

2. The disposal of this material in open lake waters would constitute a serious source of phosphorus, nitrogen and other pollutants to the lake.

3. The waters of the Fox River entering Green Bay constitute a significant source of pollution.



UPSTREAM LIMIT OF FEDERAL PROJECT
FOX
RIVER
PROJECT DEPTH 18 FT.
68-4
68-3
68-2
68-1
TURNING BASIN
PROJECT DEPTH 20 FT.
DEPERE LOCK
FOX RIVER
PROJECT DEPTH 6 FT
DEPERE
SHELL OIL CO., INC.
PROJECT DEPTH 24 FT
GREEN
BAY
U.S. HARBOR LINE
EAST
RIVER
LEGEND
AREA TO BE DREDGED
X 68-2 BOTTOM SAMPLE OBSERVED
⊗ 68-1 BOTTOM SAMPLE RETAINED
WORK REMAINING TO BE DONE SHOWN THUS
DUMPING GROUNDS:
PROJECT DEPTHS AND SOUNDINGS
ARE REFERRED TO LOW WATER DATUM
576.8 FEET ABOVE MEAN WATER LEVEL
AT FATHER POINT, QUEBEC I.G.L.D. (1955)
(INTERNATIONAL GREAT LAKES DATUM)



CHICAGO PROGRAM OFFICE
CALUMET AREA SURVEILLANCE UNIT

GREEN BAY HARBOR
WISCONSIN
SAMPLING STATIONS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS

DISCUSSION OF RESULTS

The field observations at each of the four points observed within the area to be dredged indicate that the sediments are severely polluted. All of the samples were dark grey-brown and contained fibrous material from paper mill wastes. The only life found on the bottom were a few sludgeworms at Station GRAY 68-4. The large clamshells found at this point appeared to be refuse from a passing vessel.

Color photographs of all the observed samples are on file at the Chicago Program Office of the Federal Water Pollution Control Administration.

The results of the chemical analysis of the bottom sediments at Station GRAY 68-1 confirm the field observations. All of the parameters measured indicate that the Fox River at Green Bay is one of the most severely polluted harbors on Lake Michigan.(See Table II).

Disposal of this material in Lake Michigan or the open waters of Green Bay would constitute a serious source of phosphorus, nitrogen and other pollutants to the lake.

The water at Station GRAY 68-1 did not meet several of the criteria established by the Calumet Area Enforcement Conferees for Inner Harbor Basins. It is recognized that these criteria cannot be officially applied to the Fox River at Green Bay; they are used herein only for comparison and evaluation purposes. Table III shows that maximums for Dissolved Solids, Total Phosphorus, Ammonia Nitrogen and Phenols were exceeded on May 21, 1968.

TABLE I

FIELD OBSERVATIONS OF BOTTOM SEDIMENTS
FOX RIVER
May 21, 1968

Sta.	GBAY 68-1	Depth 22' Grey-brown silt, no odor, no life - sample retained
Sta.	GBAY 68-2	Depth 15' Grey-brown silt, strong sewage odor, fibrous material, no life visible
Sta.	GBAY 68-3	Depth 16' Grey-brown silt, streaks of red clay, sewage odor, fibrous material, no life
Sta.	GBAY 68-4	Depth 11' Sandy silt, clamshells and sludgeworms, large shells, probably dumped from boat

TABLE II

RESULTS OF ANALYSIS OF BOTTOM SEDIMENTS
COLLECTED AT FOX RIVER, GREEN BAY, May 21, 1968

Station GBY 68-1

Parameter	
% Total Solids	23.91
% Volatile Solids	46.72
COD	251,823 mg/kg
Total Phosphorus	348 mg/kg
NH_3-N	548 mg/kg
NO_3-N	18 mg/kg
Org. N	6344 mg/kg
Phenol	13.5 mg/kg
Oil and Grease	6880 mg/kg
Cyanide	0.66 mg/kg
Sulfide	234 mg/kg
Total Iron	15,246 mg/kg
Copper	7.1 mg/kg
Cadmium	0.79 mg/kg
Nickel	58 mg/kg
Zinc	251 mg/kg
Lead	158 mg/kg
Chromium	146 mg/kg

All results are reported on a DRY basis.

TABLE III

RESULTS OF ANALYSIS OF WATER SAMPLES
COLLECTED AT FOX RIVER, GREEN BAY, May 21, 1968

Station GBAY 68-1

Parameter	Station GBAY 68-1	Criteria
Temp. °C	16	not more than 29.6
pH	8.2	within range 7.5-9.0
Suspended Solids	19 mg/l	
Dissolved Solids	235 mg/l	not more than 230 mg/l
Turbidity	9.0 units*	
MBAS	0.05 mg/l	not more than 0.30 mg/l
Chloride	8.5 mg/l	not more than 30 mg/l
Sulfate	28 mg/l	not more than 75 mg/l
COD	30 mg/l	
Total Phosphorus	0.104 mg/l	not more than 0.033 mg/l
NH_3-N	0.22 mg/l	not more than 0.12 mg/l
NO_2+NO_3-N	0.06 mg/l	
Org. N	0.80 mg/l	
Phenolics	6 µg/l	not more than 5 µg/l
Oil and Grease	2.0 mg/l	
Cyanide	NF	not more than 0.1 mg/l
Total Iron	0.54 mg/l	
Copper	0.17 mg/l	
Cadmium	NF	
Nickel	0.06 mg/l	
Zinc	0.08 mg/l	
Lead	0.01 mg/l	
Chromium	0.03 mg/l	

*Turbidity is expressed in APHA units, equivalent to Jackson units.
NF - not detected within sensitivity of test.

LOCATION OF SAMPLING POINTS
FOX RIVER AT GREEN BAY

May 21, 1968

Sta.	GRAY 68-1	Mid-channel, 200 feet upstream of buoys 7 and 8. Lat. 44°-29'-45" Long. 88°-01'-53"
Sta.	GRAY 68-2	Mid-channel, midway between buoys 10 and 12. Lat. 44°-29'-57" Long. 88°-02'-14"
Sta.	GRAY 68-3	Mid-channel, between buoys 13 and 14. Lat. 44°-28'-11" Long. 88°-02'-38"
Sta.	GRAY 68-4	Mid-channel, 700 feet downstream from buoy 16. Lat. 44°-28'-21" Long. 88°-02'-45"

APPENDIX A 14

REPORT ON THE DEGREE OF POLLUTION OF BOTTOM
SEDIMENTS IN WAUKEGAN HARBOR

March 29, 1968

April 1968

Federal Water Pollution Control Administration
Great Lakes Region
Chicago Program Office

In accordance with an agreement between the Federal Water Pollution Control Administration and the United States Army Corps of Engineers that the Federal Water Pollution Control Administration would determine the degree of pollution of bottom sediments in harbors to be dredged by the Corps of Engineers, personnel of the Chicago Program Office sampled Waukegan Harbor on March 29, 1968. The points sampled represent areas scheduled for dredging on a map provided by the Corps of Engineers.

Members of the sampling crew were:

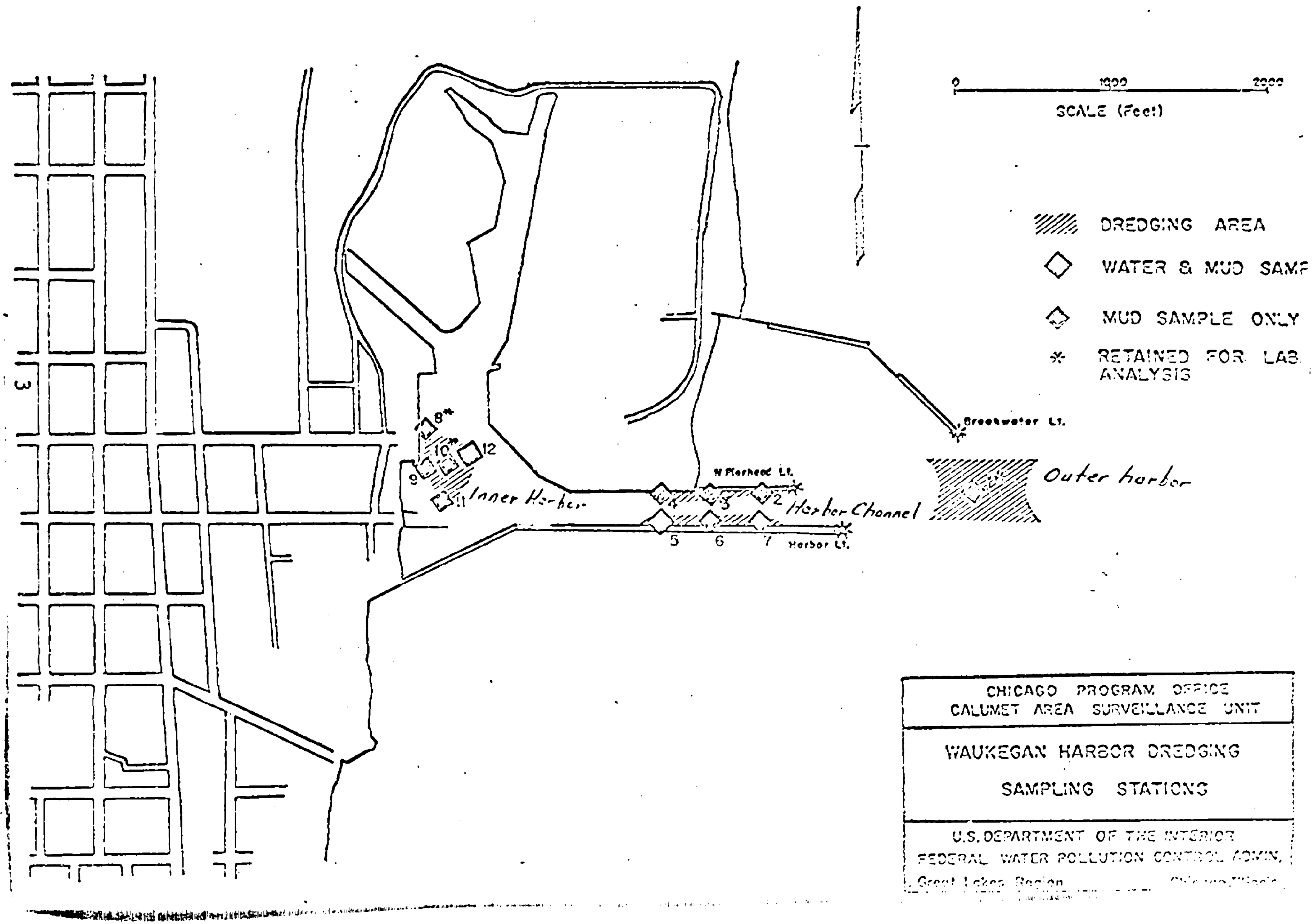
Robert J. Bowden - Sanitary Engineer
Joseph V. Slovick - Hydraulic Technician
Daniel Chorowicki - Boat Operator-Sampler

CONCLUSIONS AND RECOMMENDATIONS

1. The material inside the harbor is severely polluted and should not be disposed of in Lake Michigan.

2. The material in the outer channel, off the breakwater light, is not severely polluted.

3. The material along both sides of the harbor channel contains a large number of rocks that apparently came from the breakwater or bulkhead and some finer material which has been affected by pollution from the harbor.


0
1000
2000
SCALE (Feet)
DREDGING AREA
WATER & MUD SAMP
MUD SAMPLE ONLY
* RETAINED FOR LAB ANALYSIS
Breakwater Lt.
Outer harbor
N Pierhead Lt.
Harbor Channel
Harbor Lt.
Inner Harbor
1
2
3
4
5
6
7
8*
9
10*
11
12
CHICAGO PROGRAM OFFICE
CALUMET AREA SURVEILLANCE UNIT
WAUKEGAN HARBOR DREDGING
SAMPLING STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.

Discussion of Field Observations and Previous Sampling (See Table 1)

The bottom in the outer harbor consists of light brown sand that probably drifted into the channel from other portions of the Lake. It did not appear to be polluted. This result agrees with the result of a survey made on May 15, 1967.

The bottom in the areas to be dredged along the north and south walls of the harbor channel is covered with large rocks. Three attempts were made at each of six different points (Wauk. 68-2 thru Wauk. 68-7) to obtain a sample. One light brown rock, 3" in diameter, was found at station Wauk. 68-3 and a large flat rock, approximately 12" X 6" X 3" thick, was found at station Wauk. 68-5. Both of these rocks appear to be of the same material that makes up the breakwater and bulkhead. The rocks on the bottom made it impossible to collect a sample of the finer materials with the equipment available. Samples collected on May 15, 1967 near stations Wauk. 68-2 and Wauk. 68-5 indicated a dark grey sandy bottom that had been affected by pollution from the harbor but was not as polluted as the harbor bottom muds.

Five samples collected within the harbor appear to be heavily polluted. (stations Wauk. 68-8 thru Wauk. 68-12, See Table 1).

Discussion of Laboratory Results

The laboratory results confirm the findings of the field observations. At station 68-1 (see Table 2) the high percent solids indicates a well-drained or sandy sample and the low percent volatile solids indicates that there is little organic material.

The samples collected inside the harbor (Wauk. 68-8 and Wauk. 68-12) have a low percentage of solids and a high percentage of volatile solids, indicating a finer material with more organic material. Total phosphorus, COD, ammonia nitrogen, organic nitrogen, phenol, oil and grease, cyanide, sulfide, total iron, copper, lead and chromium are all substantially higher inside the harbor. The disposal of material dredged from within the harbor in Lake Michigan would add substantial amounts of nutrients and oil and grease to the lake.

Water samples collected in the harbor (Sta. Wauk. 68-12) and the channel (Sta. 68-5) indicate that there was no substantial difference in water quality between the two points (see table 3). The quality of the water meets the criteria for inner harbor basins established by the Calumet Area Enforcement Conference except for total phosphorus and ammonia nitrogen. It is recognized that these criteria are not officially applicable to Waukegan Harbor and are used only for the purpose of evaluating the quality of the water in the harbor. The quality of the water is generally satisfactory but action must be taken to reduce the amount of phosphorus reaching Lake Michigan from Waukegan.

TABLE 1

FIELD OBSERVATIONS OF BOTTOM SEDIMENTS
WAUKEGAN HARBOR
March 29, 1968

Sta. Wauk. 68-1	Depth 26 feet - light brown sand, some black specks, no odor - sample saved for analysis.
Sta. Wauk. 68-2	Depth 8.5 feet - bottom hard, no sample after 3 dips.
Sta. Wauk. 68-3	Depth 11 feet - bottom hard, one small brown rock in 3 dips.
Sta. Wauk. 68-4	Depth 13 feet - bottom hard, no sample after 3 dips.
Sta. Wauk. 68-5	Depth 14 feet - bottom hard, one large rock in 3 dips; water sample taken to indicate quality of harbor channel.
Sta. Wauk. 68-6	Depth 10 feet - bottom hard; no sample after 3 dips.
Sta. Wauk. 68-7	Depth 16 feet - bottom hard; no sample after 3 dips.
Sta. Wauk. 68-8	Depth 15 feet - dark grey oily silt; slight petroleum odor; sample retained for laboratory analysis.
Sta. Wauk. 68-9	Depth 25 feet - dark grey-brown silt; some sand and leaves; little odor.
Sta. Wauk. 68-10	Depth 25 feet - dark grey silt; little odor; sample retained for laboratory analysis.
Sta. Wauk. 68-11	Depth 25 feet - dark grey silt; little odor.
Sta. Wauk. 68-12	Depth 25 feet - dark grey silt; little odor; water sample collected to indicate quality in harbor.

TABLE 2

RESULTS OF ANALYSIS OF BOTTOM SEDIMENT SAMPLES
COLLECTED IN WAUKEGAN HARBOR March 29, 1968

Station Parameter	Wauk. 68-1 mg/kg	Wauk. 68-8 mg/kg	Wauk. 68-12 mg/kg
% Solids	72.9%	34.0%	36.7%
% Volatile Solids	2.1%	12.9%	14.1%
T. Sol. Phosphorus	1.00	1.47	1.64
Total Phosphorus	174	856	1070
COD	19,100	145,500	157,000
NH_3-N	16	106	183
NO_3-N	2.3	3.8	2.5
Organic-N	310	1,253	1,687
Phenol	0.252	1.57	1.15
Oil & Grease	1008	8061	11,093
Cyanide	0.15	2.5	0.68
Sulfide	1.96	70.0	110
Total Iron	7,420	26,400	25,400
Cu	*	65	46
Cd	*	*	*
Ni	*	*	*
Zn	81	200	297
Pb	15	425	837
Cr	*	62	44

Results reported on DRY basis

* Indicates none found within sensitivity of test

TABLE 3

RESULTS OF ANALYSIS OF WATER SAMPLES
COLLECTED IN WAUKEGAN HARBOR March 29, 1968

Station	Wauk. 68-5 mg/l	Wauk. 68-12 mg/l
Parameter		
pH	7.5	8.2
Temp. °C	9	9
Dissolved Solids	193	201
Suspended Solids	21	18
Turbidity	9.4	5.3
Spec. Conductance	330	340
T. Sol. Phosphorus	0.040	0.038
Total Phosphorus	0.096	0.092
COD	23	26
NH_3-N	0.38	0.77
NO_3-N	0.39	0.34
Organic-N	0.36	0.53
Phenol (ug/l)	2	4
Cyanide	0.01	0.02
Total Iron	0.40	0.33
Cu	0.05	0.02
Cd	*	*
Ni	*	*
Zn	0.04	*
Pb	*	*
Cr	0.02	0.10
SO_4	0.25	0.27
Cl	7.0	8.5
MBAS	0.10	0.12

* Indicates none found within sensitivity of test

TABLE 4

LOCATION OF SAMPLING POINTS

WAUKEGAN HARBOR
March 29, 1968

Sta. Wauk. 68-1 Outer harbor 450' south of breakwater light
Lat. 42°-21'-40"
Long. 87°-48'-37"

Sta. Wauk. 68-2 Harbor channel 10 feet from north bulkhead
Lat. 42°-21'-40"
Long. 87°-48'-54"

Sta. Wauk. 68-3 Harbor channel 10 feet from north bulkhead
Lat. 42°-21'-40"
Long. 87°-48'-58"

Sta. Wauk. 68-4 Harbor channel 10 feet from north bulkhead
Lat. 42°-21'-40"
Long. 87°-49'-03"

Sta. Wauk. 68-5 Harbor channel 10 feet from south breakwater
Lat. 42°-21'-39"
Long. 87°-49'-03"

Sta. Wauk. 68-6 Harbor channel 10 feet from south breakwater
Lat. 42°-21'-39"
Long. 87°-48'-58"

Sta. Wauk. 68-7 Harbor channel 10 feet from south breakwater
Lat. 42°-21'-39"
Long. 87°-48'-54"

Sta. Wauk. 68-8 Waukegan Harbor 20 feet east of bulkhead at foot of Clayton Street
Lat. 42°-21'-45"
Long. 87°-49'-24"

Sta. Wauk. 68-9 Waukegan Harbor 20 feet southeast of corner in bulkhead at Waukegan Yacht Club
Lat. 42°-21'-42"
Long. 87°-49'-24"

Sta. Wauk. 68-10 Waukegan Harbor 200 feet east of bulkhead
Lat. 42°-21'-43"
Long. 87°-49'-23"

TABLE 4 (cont'd)

Sta. Wauk. 68-11 Waukegan Harbor 300 feet southeast of corner in bulkhead at Waukegan Yacht Club
Lat. 42°-21'-40"
Long. 87°-49'-23"

Sta. Wauk. 68-12 Waukegan Harbor 350' east of bulkhead
Lat. 42°-21'-43"
Long. 87°-49'-21"

APPENDIX A 14

REPORT ON THE DEGREE OF POLLUTION OF BOTTOM
SEDIMENTS IN WAUKEGAN HARBOR

March 29, 1968

April 1968

Federal Water Pollution Control Administration
Great Lakes Region
Chicago Program Office

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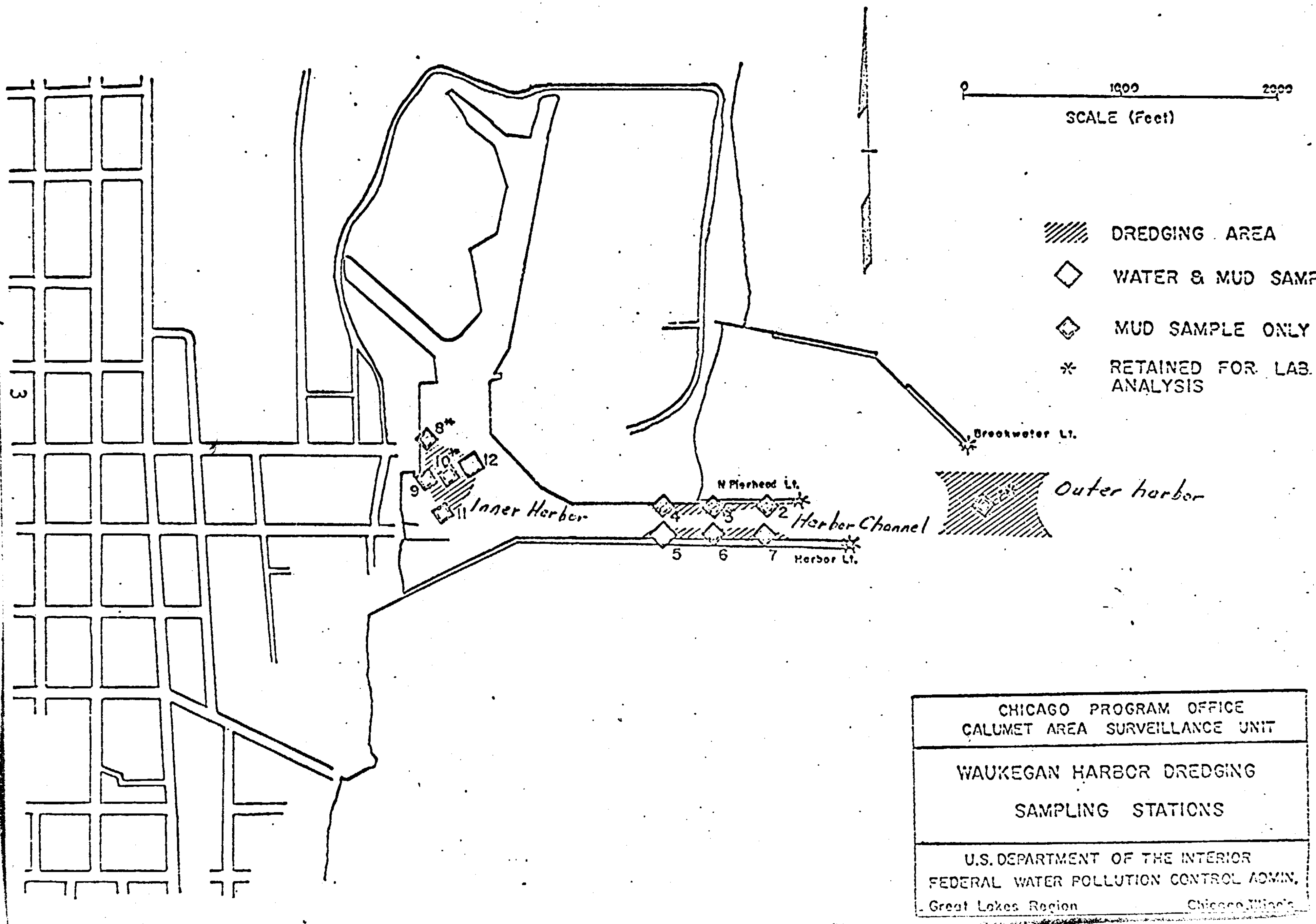
1. The material inside the harbor is severely polluted and should not be disposed of in Lake Michigan.

2. The material in the outer channel, off the breakwater light, is not severely polluted.

3. The material along both sides of the harbor channel contains a large number of rocks that apparently came from the breakwater or bulkhead and some finer material which has been affected by pollution from the harbor.


0
1000
2000
SCALE (Feet)
DREDGING AREA
WATER & MUD SAMP
MUD SAMPLE ONLY
RETAINED FOR LAB. ANALYSIS
Breakwater Lt.
Outer harbor
N Pierhead Lt.
Harbor Channel
Harbor Lt.
Inner Harbor
8*
10*
12
9
11
4
3
2
5
6
7
3
CHICAGO PROGRAM OFFICE
CALUMET AREA SURVEILLANCE UNIT
WAUKEGAN HARBOR DREDGING
SAMPLING STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois

Discussion of Field Observations and Previous Sampling (See Table 1)

The bottom in the outer harbor consists of light brown sand that probably drifted into the channel from other portions of the Lake. It did not appear to be polluted. This result agrees with the result of a survey made on May 15, 1967.

The bottom in the areas to be dredged along the north and south walls of the harbor channel is covered with large rocks. Three attempts were made at each of six different points (Wauk. 68-2 thru Wauk. 68-7) to obtain a sample. One light brown rock, 3" in diameter, was found at station Wauk. 68-3 and a large flat rock, approximately 12" X 6" X 3" thick, was found at station Wauk. 68-5. Both of these rocks appear to be of the same material that makes up the breakwater and bulkhead. The rocks on the bottom made it impossible to collect a sample of the finer materials with the equipment available. Samples collected on May 15, 1967 near stations Wauk. 68-2 and Wauk. 68-5 indicated a dark grey sandy bottom that had been affected by pollution from the harbor but was not as polluted as the harbor bottom muds.

Five samples collected within the harbor appear to be heavily polluted. (stations Wauk. 68-8 thru Wauk. 68-12, See Table 1).

Discussion of Laboratory Results

The laboratory results confirm the findings of the field observations. At station 68-1 (see Table 2) the high percent solids indicates a well-drained or sandy sample and the low percent volatile solids indicates that there is little organic material.

The samples collected inside the harbor (Wauk. 68-8 and Wauk. 68-12) have a low percentage of solids and a high percentage of volatile solids, indicating a finer material with more organic material. Total phosphorus, COD, ammonia nitrogen, organic nitrogen, phenol, oil and grease, cyanide, sulfide, total iron, copper, lead and chromium are all substantially higher inside the harbor. The disposal of material dredged from within the harbor in Lake Michigan would add substantial amounts of nutrients and oil and grease to the lake.

Water samples collected in the harbor (Sta. Wauk. 68-12) and the channel (Sta. 68-5) indicate that there was no substantial difference in water quality between the two points (see table 3). The quality of the water meets the criteria for inner harbor basins established by the Calumet Area Enforcement Conference except for total phosphorus and ammonia nitrogen. It is recognized that these criteria are not officially applicable to Waukegan Harbor and are used only for the purpose of evaluating the quality of the water in the harbor. The quality of the water is generally satisfactory but action must be taken to reduce the amount of phosphorus reaching Lake Michigan from Waukegan.

TABLE 1

FIELD OBSERVATIONS OF BOTTOM SEDIMENTS
WAUKEGAN HARBOR
March 29, 1968

Sta. Wauk. 68-1	Depth 25 feet - light brown sand, some black specks, no odor - sample saved for analysis.
Sta. Wauk. 68-2	Depth 8.5 feet - bottom hard, no sample after 3 dips.
Sta. Wauk. 68-3	Depth 11 feet - bottom hard, one small brown rock in 3 dips.
Sta. Wauk. 68-4	Depth 13 feet - bottom hard, no sample after 3 dips.
Sta. Wauk. 68-5	Depth 14 feet - bottom hard, one large rock in 3 dips; water sample taken to indicate quality of harbor channel.
Sta. Wauk. 68-6	Depth 10 feet - bottom hard; no sample after 3 dips.
Sta. Wauk. 68-7	Depth 16 feet - bottom hard; no sample after 3 dips.
Sta. Wauk. 68-8	Depth 15 feet - dark grey oily silt; slight petroleum odor; sample retained for laboratory analysis.
Sta. Wauk. 68-9	Depth 25 feet - dark grey-brown silt; some sand and leaves; little odor.
Sta. Wauk. 68-10	Depth 25 feet - dark grey silt; little odor; sample retained for laboratory analysis.
Sta. Wauk. 68-11	Depth 25 feet - dark grey silt; little odor.
Sta. Wauk. 68-12	Depth 25 feet - dark grey silt; little odor; water sample collected to indicate quality in harbor.

TABLE 2

RESULTS OF ANALYSIS OF BOTTOM SEDIMENT SAMPLES
COLLECTED IN WAUKEGAN HARBOR March 29,1968

Station Parameter	Wauk. 68-1 mg/kg	Wauk. 68-8 mg/kg	Wauk. 68-12 mg/kg
% Solids	72.9%	34.0%	36.7%
% Volatile Solids	2.1%	12.9%	14.1%
T. Sol. Phosphorus	1.00	1.47	1.64
Total Phosphorus	174	856	1070
COD	19,100	145,500	157,000
NH_3-N	16	106	183
NO_3-N	2.3	3.8	2.5
Organic-N	310	1,253	1,687
Phenol	0.252	1.57	1.15
Oil & Grease	1003	8061	11,093
Cyanide	0.15	2.5	0.68
Sulfide	1.96	70.0	110
Total Iron	7,420	26,400	25,400
Cu	*	65	46
Cd	*	*	*
Ni	*	*	*
Zn	81	200	297
Pb	15	425	837
Cr	*	62	44

Results reported on DRY basis

* Indicates none found within sensitivity of test

TABLE 3

RESULTS OF ANALYSIS OF WATER SAMPLES
COLLECTED IN WAUKEGAN HARBOR March 29, 1968

Station	Wauk. 68-5 mg/l	Wauk. 68-12 mg/l
Parameter		
pH	7.5	8.2
Temp. °C	9	9
Dissolved Solids	193	201
Suspended Solids	21	18
Turbidity	9.4	5.3
Spec. Conductance	330	340
T. Sol. Phosphorus	0.040	0.038
Total Phosphorus	0.096	0.092
COD	23	26
NH_3-N	0.38	0.77
NO_3-N	0.39	0.34
Organic-N	0.36	0.53
Phenol (ug/l)	2	4
Cyanide	0.01	0.02
Total Iron	0.40	0.33
Cu	0.05	0.02
Cd	*	*
Ni	*	*
Zn	0.04	*
Pb	*	*
Cr	0.02	0.10
SO_4	0.25	0.27
Cl	7.0	8.5
MBAS	0.10	0.12

* Indicates none found within sensitivity of test

TABLE 4

LOCATION OF SAMPLING POINTS

WAUKEGAN HARBOR
March 29, 1968

Sta. Wauk. 68-1 Outer harbor 450' south of breakwater light
Lat. 42°-21'-40"
Long. 87°-48'-37"

Sta. Wauk. 68-2 Harbor channel 10 feet from north bulkhead
Lat. 42°-21'-40"
Long. 87°-48'-54"

Sta. Wauk. 68-3 Harbor channel 10 feet from north bulkhead
Lat. 42°-21'-40"
Long. 87°-48'-58"

Sta. Wauk. 68-4 Harbor channel 10 feet from north bulkhead
Lat. 42°-21'-40"
Long. 87°-49'-03"

Sta. Wauk. 68-5 Harbor channel 10 feet from south breakwater
Lat. 42°-21'-39"
Long. 87°-49'-03"

Sta. Wauk. 68-6 Harbor channel 10 feet from south breakwater
Lat. 42°-21'-39"
Long. 87°-48'-58"

Sta. Wauk. 68-7 Harbor channel 10 feet from south breakwater
Lat. 42°-21'-39"
Long. 87°-48'-54"

Sta. Wauk. 68-8 Waukegan Harbor 20 feet east of bulkhead at foot of Clayton Street
Lat. 42°-21'-45"
Long. 87°-49'-24"

Sta. Wauk. 68-9 Waukegan Harbor 20 feet southeast of corner in bulkhead at Waukegan Yacht Club
Lat. 42°-21'-42"
Long. 87°-49'-24"

Sta. Wauk. 68-10 Waukegan Harbor 200 feet east of bulkhead
Lat. 42°-21'-43"
Long. 87°-49'-23"

TABLE 4 (cont'd)

Sta. Wauk. 68-11 Waukegan Harbor 300 feet southeast of corner in bulkhead at Waukegan Yacht Club

Lat. 42°-21'-40"
Long. 87°-49'-23"

Sta. Wauk. 68-12 Waukegan Harbor 350' east of bulkhead
Lat. 42°-21'-43"
Long. 87°-49'-21"

APPENDIX A 15

REPORT ON THE DEGREE OF POLLUTION OF BOTTOM
SEDIMENTS IN KENOSHA HARBOR
April 24, 1968

May 1968

Federal Water Pollution Control Administration
Great Lakes Region
Chicago Program Office

In accordance with an agreement between the Federal Water Pollution Control Administration and the United States Army Corps of Engineers that the Federal Water Pollution Control Administration would determine the degree of pollution of bottom sediments in harbors to be dredged by the Corps of Engineers, personnel of the Chicago Program Office sampled Kenosha Harbor on April 24, 1968. The points sampled represent areas scheduled for dredging on a map provided by the Corps of Engineers.

Members of the sampling crew were:

Robert J. Bowden - Sanitary Engineer
Joseph V. Slovick - Hydraulic Technician
Daniel Chorowicki - Boat Operator - Sampler
Steven Pardieck - Engineer

CONCLUSIONS AND RECOMMENDATIONS

1. There has been no serious shoaling in the area indicated for maintenance dredging and the need for such dredging should be investigated.

2. The clays on the harbor bottom show moderate pollution from parameters indicating industrial wastes but do not contain high concentrations of nutrients.

3. The water entering Lake Michigan from Kenosha Harbor met reasonable criteria for inner harbor waters and did not constitute a serious pollution source on April 24, 1968.

4. If maintenance dredging is required, it is minimal and the spoil would not add substantial amounts of nutrients to the Lake if it was disposed of in the normal dumping area.

These comments apply only to sediments in the area outlined on the map on page 4 . Sediments in the inner harbor were not sampled and may be severely polluted.

DISCUSSION OF RESULTS

The bottom sediments at each of the four points consisted of a grey clay which had a strong fish odor and a large population of sludgeworms (see Table 1). All of the samples were taken at a depth of 27 feet or greater and no evidence of shoaling sand was found. A considerable amount of light brown sand was found in the harbor on May 3, 1967 (see page 9) but none was found on April 24, 1968. Maintenance dredging may not be required during 1968.

The station selected for analysis of the bottom sediment was Station KEN 68-1 which is the most upstream station (see map, page 4) and, presumably, the most seriously polluted station. The results (Table 2) indicate moderate pollution with considerable COD, oil and grease and iron concentrations. Concentrations of phosphorus, phenol, cyanide and sulphide were moderate.

The large population of sludgeworms indicates the presence of considerable amounts of organic material but little or no toxic materials. The concentration of phosphorus was lower than concentrations found in other harbors. This may indicate that the clay is not the result of sedimentation but is a natural formation exposed by currents or previous dredging.

Photographs of all of the mud samples are on file at the Chicago Program Office.

The water in the harbor met the criteria adopted by the Calumet Area Conferees for "Inner Harbor Basins." These criteria are used for comparison purposes only, they are not officially applicable to Kenosha Harbor. The results of the analysis of the water sample (see Table 3) show that the water entering Lake Michigan from Kenosha Harbor was not polluted on the day the sample was collected.

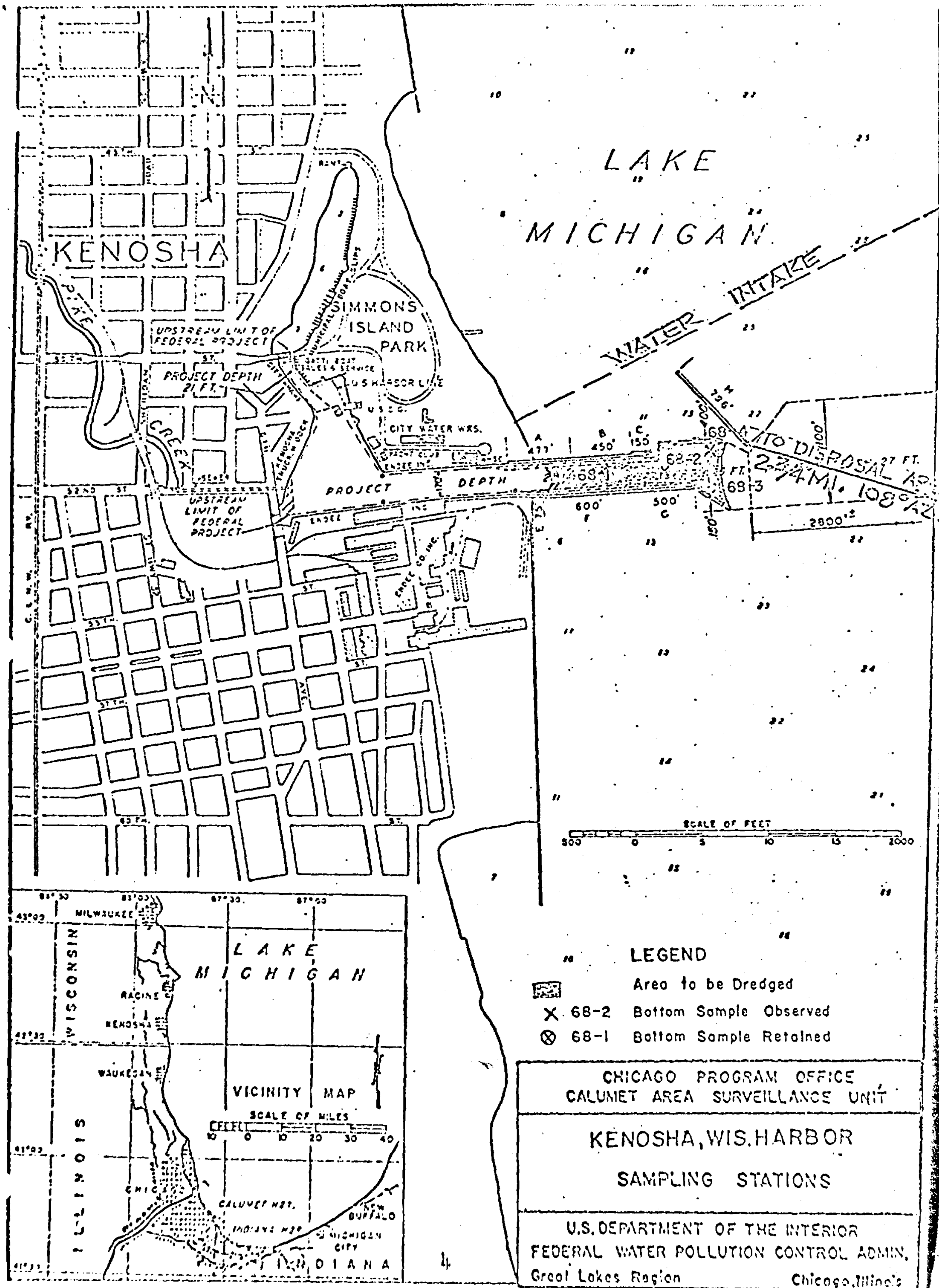

LAKE MICHIGAN
KENOSHA
SIMMONS ISLAND PARK
WATER INTAKE
PIKE CREEK
UPSTREAM LIMIT OF FEDERAL PROJECT
PROJECT DEPTH 21 FT.
PROJECT DEPTH
U.S. HARBOR LINE
CITY WATER WRS.
TO DISPOSAL AREA
2 3/4 MI. 108° AZ.
68-1
68-2
68-3
SCALE OF FEET
LAKE MICHIGAN
VICINITY MAP
SCALE OF MILES
MILWAUKEE
RACINE
KENOSHA
WAUKEGAN
WISCONSIN
ILLINOIS
INDIANA
CALUMET HBR.
INDIANA HBR.
MICHIGAN CITY
NEW BUFFALO
LEGEND
Area to be Dredged
68-2 Bottom Sample Observed
68-1 Bottom Sample Retained
CHICAGO PROGRAM OFFICE
CALUMET AREA SURVEILLANCE UNIT
KENOSHA, WIS. HARBOR
SAMPLING STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois

TABLE 1

FIELD OBSERVATIONS OF BOTTOM SEDIMENTS
KENOSHA HARBOR

April 24, 1968

Sta. KEN 68-1	Depth 28 feet Grey silt, some oil, sludgeworms, fishy odor.
Sta. KEN 68-2	Depth 28 feet Grey silt with black specks, sludgeworms, fishy odor.
Sta. KEN 68-3	Depth 27 feet Grey clay, black spots, fishy odor.
Sta. KEN 68-4	Depth 30 feet Grey clay, black spots, sludgeworms, fishy odor.

TABLE 2

RESULTS OF ANALYSES OF BOTTOM SEDIMENT SAMPLES
COLLECTED IN KENOSHA HARBOR April 24, 1968

Station	KEN-68-1 mg/kg
Parameter	
% Total Solids	59.5
% Volatile Solids	4.9
COD	111,800
Total Sol. Phosphorus	0.61
Total Phosphorus	66.5
NH_3-N	118
NO_3-N	8.6
Org-N	939
Phenol	1.15
Oil and Grease	3,550
Cyanide	0.02
Sulfide	37
Total Iron	12,530
Copper	NF
Cadmium	1.8
Nickel	30
Zinc	138
Lead	39
Chromium (Total)	NF

NF Not detected at sensitivity of test.
All results reported on a DRY basis.

TABLE 3

RESULTS OF ANALYSIS OF WATER SAMPLES
COLLECTED IN KENOSHA HARBOR April 24, 1968

Station	KEN-68-2
Parameter	mg/l
Suspended Solids	17
Dissolved Solids	168
*Turbidity	4.0
MBAS	0.10
Chloride	8.0
Sulfate	25
COD	46
Total Sol. Phosphorus	0.04
Total Phosphorus	0.06
NH_3-N	0.05
NO_3-N	0.16
Org-N	1.0
Phenol	0.001
Oil and Grease	**
Cyanide	NF
Total Iron	0.05

*Turbidity is expressed in APHA units, equivalent to Jackson units.
** Sample bottle broken
NF- None Found

LOCATION OF SAMPLING POINTS

KENOSHA HARBOR
April 24, 1968

Sta. KEN 68-1 Mid-channel - 550' upstream from Kenosha Light
Lat. 42°-35'-18"
Long. 87°-48'-33"

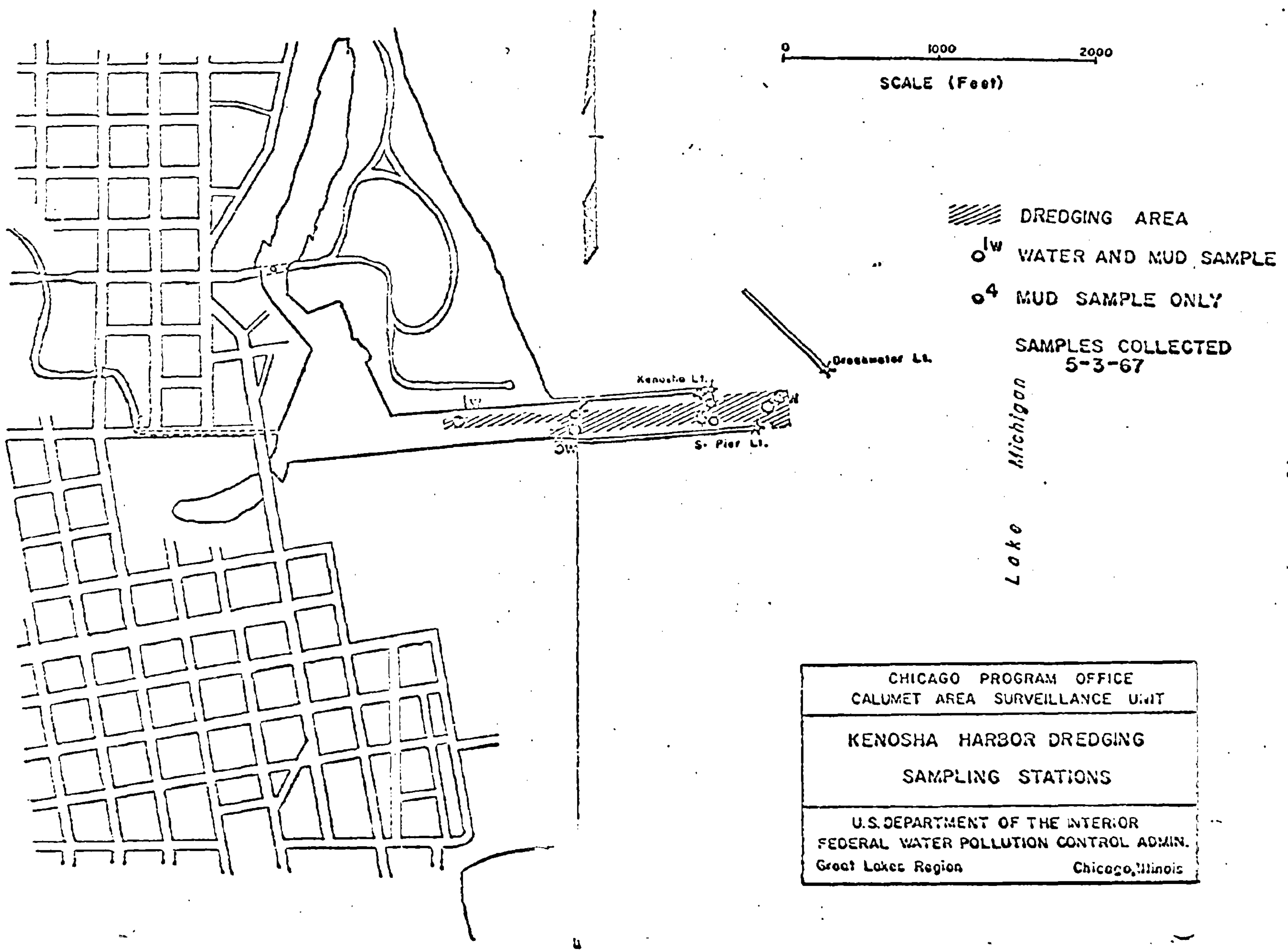
Sta. KEN 68-2 Mid-channel - between Kenosha Light and South Pier Light
Lat. 42°-35'-19"
Long. 87°-48'-29"

Sta. KEN 68-3 500' east of Kenosha Light
Lat. 42°-35'-20"
Long. 87°-48'-23"

Sta. KEN 68-4 300' east of South Pier Light
Lat. 42°-35'-17"
Long. 87°-48'-23"

FIELD OBSERVATIONS ON BOTTOM SAMPLES
KENOSHA HARBOR MAY 3, 1967

Sample		Water Depth
1W	Brown clay, some sand, no odor	20 ft.
2	Brown clean sand, no odor	22 "
3W	Dark brown oily silt and clay; sludge worms noted; slight petrol odor	23 "
4	Light brown sand, some silt, slight fish odor	22 "
5	Light brown sand, some silt, no odor	21 "
6W	Light brown sand with some black specks, no odor	25 "


0
1000
2000
SCALE (Feet)
DREDGING AREA
o1W WATER AND MUD SAMPLE
o4 MUD SAMPLE ONLY
SAMPLES COLLECTED
5-3-67
Kenosha Lt.
S. Pier Lt.
Breakwater Lt.
Lake Michigan
CHICAGO PROGRAM OFFICE
CALUMET AREA SURVEILLANCE UNIT
KENOSHA HARBOR DREDGING
SAMPLING STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois

APPENDIX A 16

FINAL
REPORT ON THE DEGREE OF POLLUTION OF BOTTOM
SEDIMENTS IN MILWAUKEE HARBOR

April 24, 1968

May 1968

Federa Water Pollution Control Administration
Great Lakes Region
Chicago Program Office

In accordance with an agreement between the Federal Water Pollution Control Administration and the United States Army Corps of Engineers that the Federal Water Pollution Control Administration would determine the degree of pollution of bottom sediments in harbors to be dredged by the Corps of Engineers, personnel of the Chicago Program Office sampled Milwaukee Harbor on April 24, 1968. The points sampled represent areas scheduled for dredging on a map provided by the Corps of Engineers.

Members of the sampling crew were:

Robert J. Bowden - Sanitary Engineer
Joseph V. Slovick - Hydraulic Technician
Daniel Chorowicki - Boat Operator-Sampler
Steven Pardieck - Engineer

PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

1. Bottom sediments in the areas to be dredged in the Kinnickinnic River are severely polluted by domestic sewage and should not be disposed of in Lake Michigan.

2. Bottom sediments in the areas to be dredged in the Menominee River are severely polluted by oil and domestic sewage and should not be disposed of in Lake Michigan.

FINAL CONCLUSIONS

The final conclusions are identical to the preliminary conclusions.

It is recommended that no dredged material from Milwaukee Harbor be disposed of in Lake Michigan.

Discussion of Field Observations

Bottom sediments in the areas to be dredged in the Kinnickinnic River consist of dark grey clay and silt and contain large populations of sludge worms and fingernail clams both of which are very pollution-tolerant organisms. Their presence in large numbers indicate the presence of a great deal of organic matter but a lack of toxic materials from industrial processes. This area of the river is seriously polluted by sewage probably from combined sewer overflows (see Table 1 - Stations MILW 68-1, 68-2 and 68-3).

Bottom sediments in the Menomonee River between 19th Street and 22nd Street consist of black silt with a strong petroleum odor. They are very heavily polluted by both industrial wastes and domestic sewage (see Table 1 Stations MILW 68-4, 68-5, 68-6, 68-7 and 68-8).

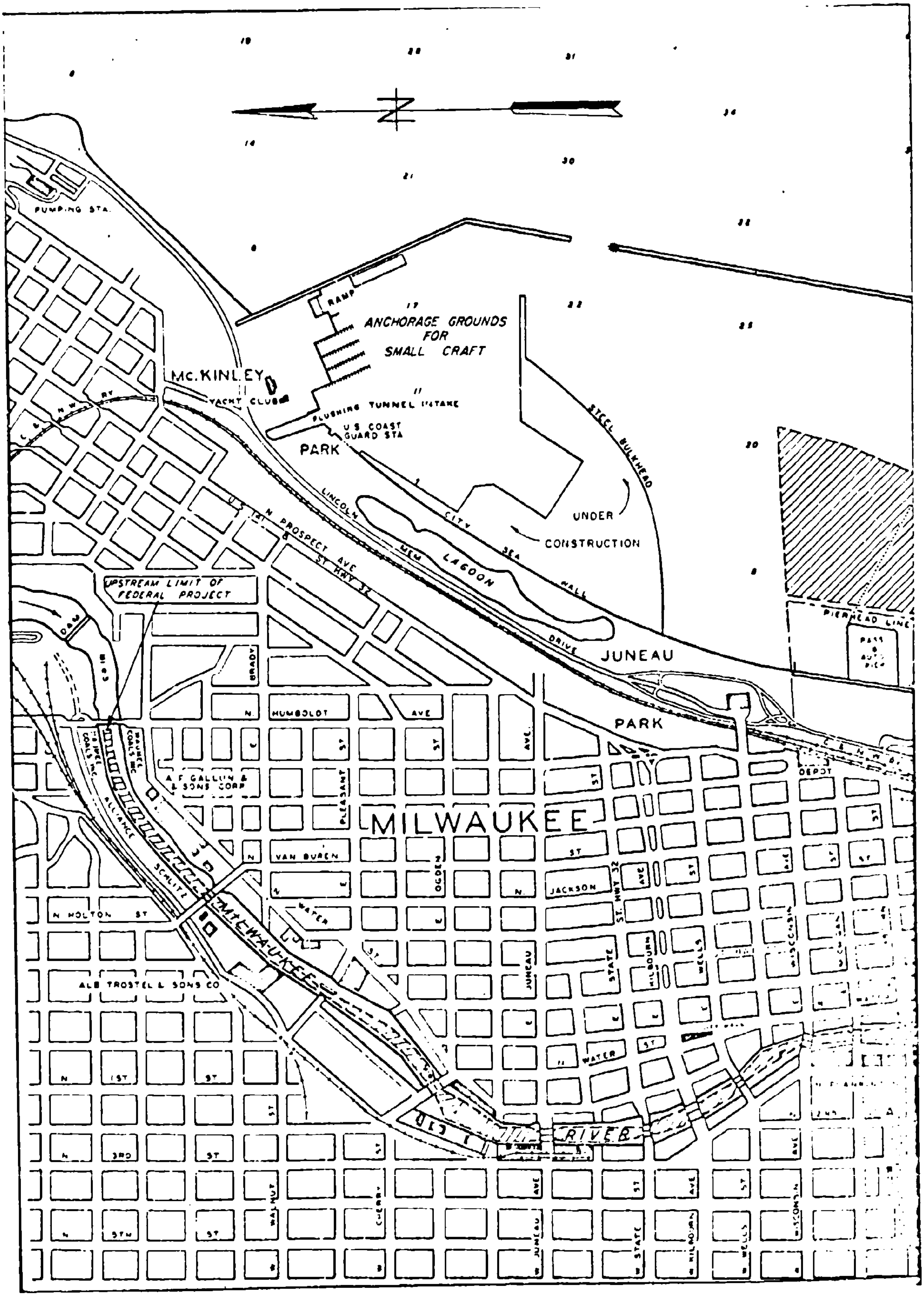
Station MILW 68-9 at 25th Street appeared to be upstream of the oil pollution but is heavily polluted by domestic sewage. The most probable source is combined sewer overflows.

Discussion of Chemical Results

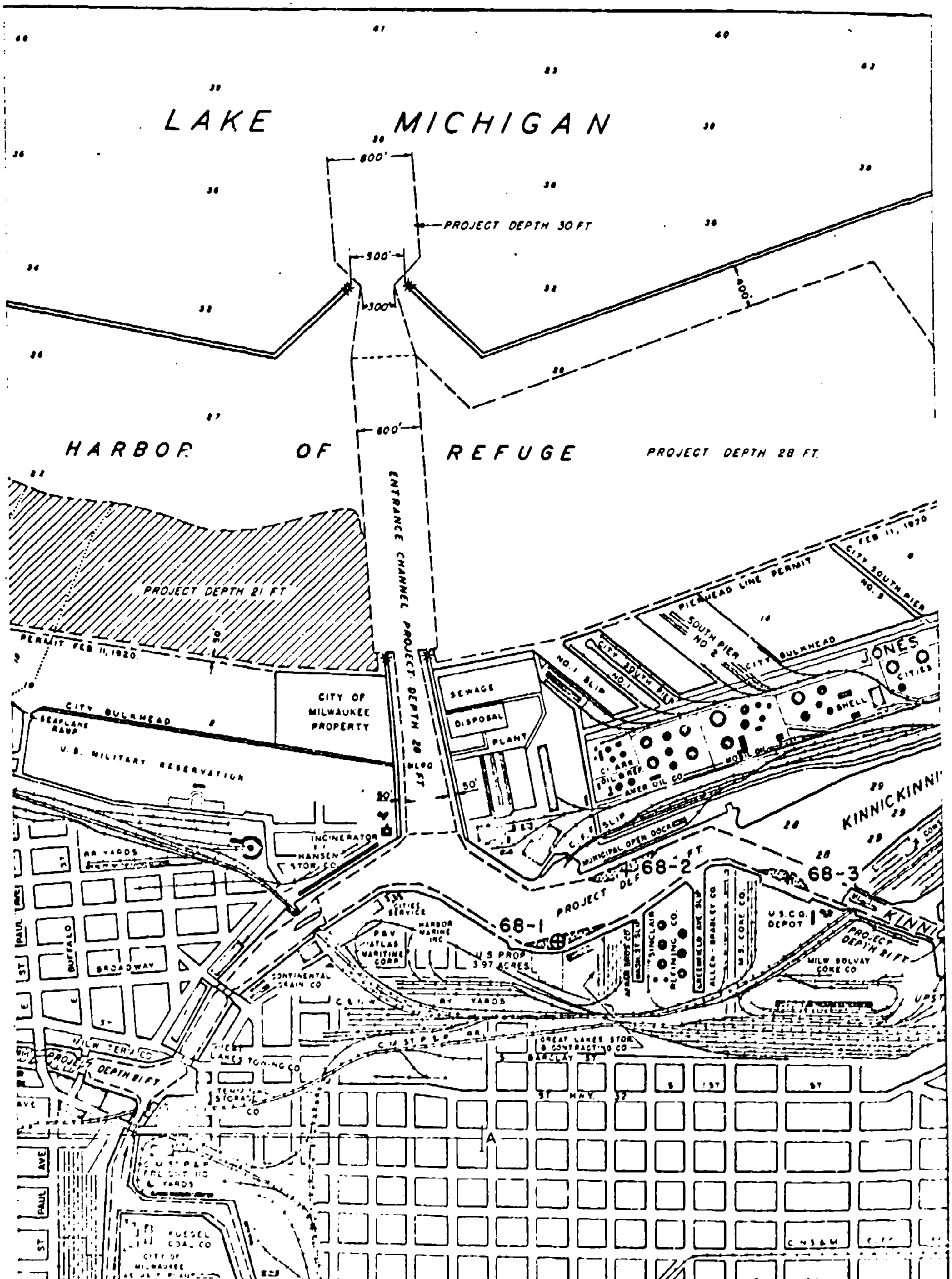
The results of the chemical analysis confirm the conclusions drawn from field observations. The area at the mouth of the Kinnickinnic River is highly polluted by domestic wastes or combined sewage overflows. Concentrations of phosphorus and sulfide at Station MILW 68-1 (see Table 2) were high and concentrations of oil and grease, iron and COD were moderately high. High concentrations of zinc and lead were also found.

All of the samples taken in the Menominee River were very heavily polluted by both domestic and municipal wastes. All of the chemical parameters measured indicate severe pollution at stations MILW 68-5 and MILW 68-8. Field observations (see Table 1) indicate that there is no substantial difference at the other stations sampled.

Bottom sediments from Milwaukee Harbor are severely polluted, and their disposal in Lake Michigan constitutes a serious source of phosphorus and other pollutants to the lake.



ANCHORAGE GROUNDS FOR SMALL CRAFT
RAMP
McKINLEY
YACHT CLUB
FLUSHING TUNNEL INTAKE
U.S. COAST GUARD STA.
PARK
PUMPING STA.
STEEL BULKHEAD
UNDER CONSTRUCTION
LINCOLN MEM. DRIVE
CITY SEA WALL
LAGOON
JUNEAU
PARK
PIERHEAD LINE
DEPOT
UPSTREAM LIMIT OF FEDERAL PROJECT
DAM
N. PROSPECT AVE
U.S. 141 & ST. HWY 32
N. HUMBOLDT AVE
BRADY
A. F. GALLUN & SONS CORP
MILWAUKEE
PLEASANT ST
VAN BUREN
OGDEN
JACKSON
ST. HWY 32
N. HOLTON ST
WATER
ALB. TROSTEL & SONS CO.
SCHLITZ
ALLIANCE
MILWAUKEE RIVER
JUNEAU
STATE
KILBOURN
WELLS
WISCONSIN
N. 1ST ST
N. 3RD ST
N. 5TH ST
WALNUT
CHERRY
JUNEAU AVE
STATE ST
KILBOURN AVE
WELLS ST
WISCONSIN AVE


LAKE MICHIGAN
800'
PROJECT DEPTH 30 FT
500'
300'
800'
HARBOR OF REFUGE
PROJECT DEPTH 28 FT.
ENTRANCE CHANNEL PROJECT DEPTH 28 FT
PROJECT DEPTH 21 FT
PERMIT FEB 11, 1920
PIERHEAD LINE PERMIT
CITY SOUTH PIER NO. 3
SOUTH PIER NO 2
CITY BULKHEAD
JONES
CITY OF MILWAUKEE PROPERTY
SEWAGE DISPOSAL PLANT
U.S. MILITARY RESERVATION
SEAPLANE RAMP
NO. 1 SLIP
CITY SOUTH PIER NO. 1
SHELL
AMER OIL CO
KINNICKINNIC
INCINERATOR
HANSEN STOR. CO
RR YARDS
MUNICIPAL OPEN DOCKS
68-1
68-2
68-3
CITIES SERVICE
HARBOR MARINE INC
ATLAS MARITIME CORP
U S PROP 3.97 ACRES
SINCLAIR REFINING CO
ALLEN - BRADLEY CO
U.S. COKE CO.
U.S.CO. DEPOT
MILW SOLVAY COKE CO
CONTINENTAL GRAIN CO
RY YARDS
GREAT LAKES STOR & CONTRACTING CO
GREAT LAKES TOWING CO
MILW TERM CO
PROJECT DEPTH 21 FT
BARCLAY ST
BROADWAY
BUFFALO
ST PAUL AVE
A

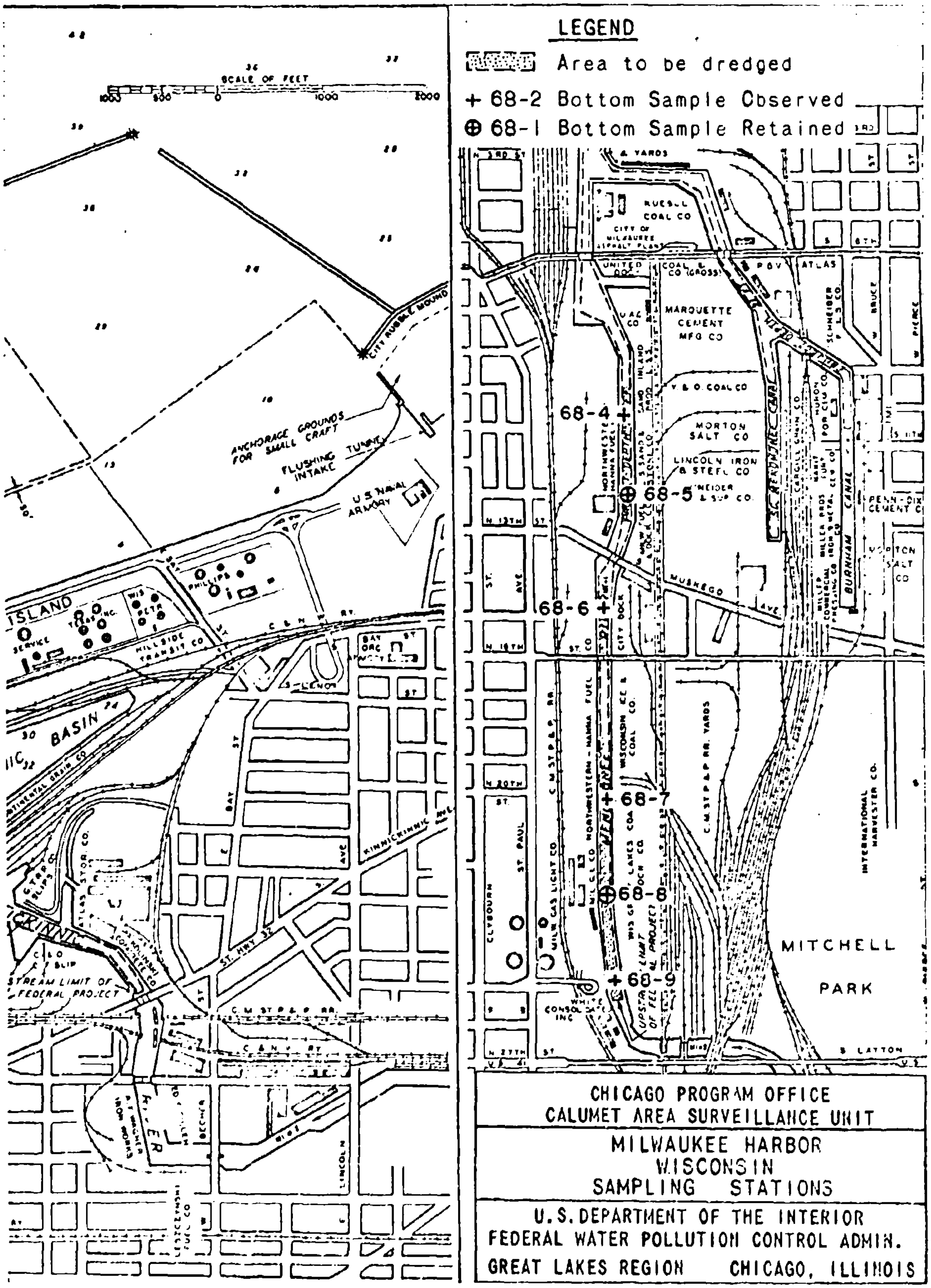

LEGEND
Area to be dredged
+ 68-2 Bottom Sample Observed
⊕ 68-1 Bottom Sample Retained
SCALE OF FEET
68-4
68-5
68-6
68-7
68-8
68-9
MITCHELL PARK
ANCHORAGE GROUNDS FOR SMALL CRAFT
FLUSHING TUNNEL INTAKE
U.S. NAVAL ARMORY
BASIN
ISLAND
MARQUETTE CEMENT MFG CO
MORTON SALT CO
LINCOLN IRON & STEEL CO
RUSSELL COAL CO
INTERNATIONAL HARVESTER CO.
BURNHAM CANAL
KINNICKINNIC AVE
MUSKEGO AVE
STREAM LIMIT OF FEDERAL PROJECT
CHICAGO PROGRAM OFFICE
CALUMET AREA SURVEILLANCE UNIT
MILWAUKEE HARBOR
WISCONSIN
SAMPLING STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS

TABLE I

FIELD OBSERVATIONS

MILWAUKEE HARBOR
(Kinnickinnic River)
April 24, 1968

Sta. MILW 68-1	Depth 25' - Grey clay; many sludgeworms; slight petroleum odor; sample retained for analysis.
Sta. MILW 68-2	Depth 29' - Dark grey silt; clams and sludgeworms; slight sewage odor.
Sta. MILW 68-3	Depth 23' - Dark grey silt; sludgeworms; little odor; some petroleum.

MILWAUKEE HARBOR
(Menominee River)
April 24,1968

Sta. MILW 68-4	Depth 21' - Black silt; grey streaks; strong petrol odor; few sludgeworms.
Sta. MILW 68-5	Depth 20' - Black silt; petroleum odor; sludgeworms; sample retained.
Sta. MILW 68-6	Depth 20' - Black silt; strong petroleum odor; gravel.
Sta. MILW 68-7	Depth 22'- Black silt; brown streaks; petroleum odor.
Sta. MILW 68-8	Depth 22' - Brown-black silt; petroleum odor; sample retained.
Sta. MILW 68-9	Depth 20' - Grey-brown silt; strong sewage odor.

TABLE 2

RESULTS OF ANALYSIS OF BOTTOM SEDIMENT SAMPLES
COLLECTED IN MILWAUKEE HARBOR April 24,1968

Station	MILW 68-1 mg/kg	MILW 68-5 mg/kg	MILW 68-8 mg/kg
Parameter			
% Total Solids	56.5	48.0	41.9
% Volatile Solids	5.7	16.2	19.3
COD	108,900	251,500	223,700
Total Sol. Phosphorus	5.01	11.20	2.43
Total Phosphorus	301	354	1,121
NH_3-N	388	281	582
NO_3-N	10.6	8.3	14
Org-N	1,607	6,118	3,157
Phenol	5.85	2.05	3.38
Oil and Grease	4,660	20,850	26,140
Cyanide	NF	0.80	1.40
Sulfide	280	1,180	465
Total Iron	12,890	19,890	19,700
Copper	NF	22	20
Cadmium	0.69	6.5	10.3
Nickel	41	56	12
Zinc	244	340	NF
Lead	165	363	360
Chromium	NF	18	40

NF Not detected within sensitivity of test.

All results reported on a DRY basis.

LOCATION OF SAMPLING POINTS

MILWAUKEE HARBOR
April 24, 1968

Sta. MILW 68-1 Kinnickinnic River - 100 feet off west bulkhead at north end of Afram Bros. building
Lat. 43°-01'-17"
Long. 87°-54'-20"

Sta. MILW 68-2 Kinnickinnic River - 100 feet off east bulkhead opposite Afram Bros. - Sinclair Refining slip.
Lat. 43°-01'-11"
Long. 87°-54'-10"

Sta. MILW 68-3 Kinnickinnic River - 150 feet off west shore, 350 feet downstream from U.S. Coast Guard Depot
Lat. 43°-00'-56"
Long. 87°-54'-12"

Sta. MILW 68-4 Menominee River - 30 feet off north bulkhead at S. Eleventh Street
Lat. 43°-01'-56"
Long. 87°-55'-29"

Sta. MILW 68-5 Menominee River - 30 feet off south bulkhead, 600 feet west of S. Eleventh St.
Lat. 43°-01'-56"
Long. 87°-55'-37"

Sta. MILW 68-6 Menominee River - 30 feet off north bulkhead, 550' east of 16th Street bridge
Lat. 43°-01'-59"
Long. 87°-55'-51"

Sta. MILW 68-7 Menominee River - midstream, 1350 feet west of 16th Street bridge
Lat. 43°-01'-59"
Long. 87°-56'-17"

Sta. MILW 68-8 Menominee River - midstream, 2350 feet west of 16th Street bridge
Lat. 43°-01'-58"
Long. 87°-56'-30"

Sta. MILW 68-9 Menominee River - midstream, 3150 feet west of 16th Street bridge
Lat. 43°-01'-57"
Long. 87°-56'-41"

APPENDIX A 17

REPORT ON THE DEGREE OF POLLUTION OF BOTTOM
SEDIMENTS IN PORT WASHINGTON HARBOR

April 24, 1968

MAY 1968

Federal Water Pollution Control Administration
Great Lakes Region
Chicago Program Office

In accordance with an agreement between the Federal Water Pollution Control Administration and the United States Army Corps of Engineers that the Federal Water Pollution Control Administration would determine the degree of pollution of bottom sediments in harbors to be dredged by the Corps of Engineers, personnel of the Chicago Program Office sampled Port Washington Harbor on April 24, 1968. The points sampled represent areas scheduled for dredging on a map provided by the Corps of Engineers.

Members of the sampling crew were:

Robert J. Bowden - Sanitary Engineer
Joseph V. Slovick - Hydraulic Technician
Daniel Chorowicki - Boat Operator-Sampler
Steven Pardieck - Engineer

CONCLUSIONS AND RECOMMENDATIONS

1. The bottom sediments in Port Washington Harbor are not as severely polluted as those found in other Lake Michigan harbors.

2. The disposal of these sediments in Lake Michigan would not add substantial amounts of nutrients to the Lake.

3. The water quality at Port Washington meets reasonable criteria and does not constitute a serious source of pollution except that the amount of phosphorus should be reduced.

DISCUSSION OF RESULTS

The sediments in Port Washington harbor were sampled in each of the three areas designated for maintenance dredging by the Corps of Engineers (see map, page 4). Field observations (Table 1) show greater amounts of sand and less grey silty material at stations PWASH 68-2 and PWASH 68-3. This indicates that these points are less affected by pollution than Sta. PWASH 68-1 which is at the mouth of the inner harbor. All of the samples contained large populations of sludgeworms.

Sediment from station PWASH 68-1 was selected for chemical analysis because it is presumed to be the most polluted. A water sample was also taken at station PWASH 68-1 to indicate the quality of the water being discharged to Lake Michigan from Sauk Creek and Port Washington harbor.

The sediment at Sta. PWASH 68-1 was not severely polluted. It contained moderate concentrations of COD and Sulphide and relatively low concentrations of phosphorus, nitrogen, phenol, cyanide and total iron. The term "relatively low concentrations" as used herein means that these concentrations are lower than concentrations found in sediments in other harbors on Lake Michigan. It does not mean that these concentrations are low when compared to natural conditions or that the harbor sediments are completely free of pollution.

The water quality at Sta. PWASH 68-1 met the criteria for inner harbor basins established by the Calumet Area Enforcement Conference except for the criterion on total phosphorus. These criteria are used for comparisonpurposes only. They cannot be officially applied to the waters of Port Washington harbor. On April 24, 1968 the water being discharged to Lake Michigan from Port Washington harbor did not constitute a serious source of pollution but action is required to reduce the amount of phosphorus discharged to Sauk Creek and the harbor.

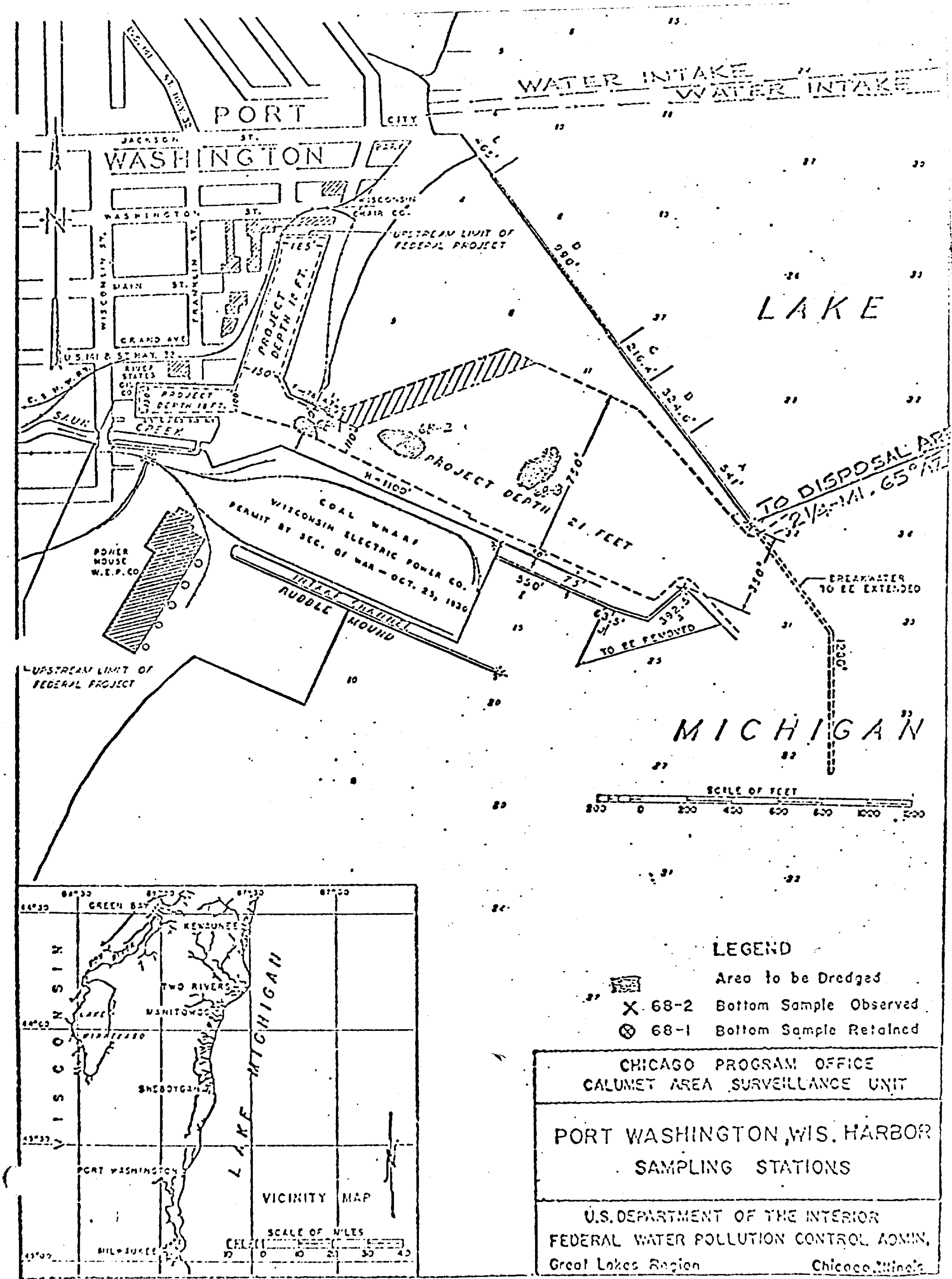

WATER INTAKE
WATER INTAKE
PORT
WASHINGTON
JACKSON ST.
WASHINGTON ST.
MAIN ST.
GRAND AVE
WISCONSIN ST.
FRANKLIN ST.
CITY
PARK
WISCONSIN CHAIR CO.
UPSTREAM LIMIT OF FEDERAL PROJECT
PROJECT DEPTH 18 FT.
PROJECT DEPTH 18 FT.
SAUK CREEK
LAKE
MICHIGAN
68-2
68-3
PROJECT DEPTH 21 FEET
COAL WHARF
WISCONSIN ELECTRIC POWER CO.
PERMIT BY SEC. OF WAR - OCT. 25, 1930
INTAKE CHANNEL
RUBBLE MOUND
POWER HOUSE W.E.P. CO.
TO BE REMOVED
BREAKWATER TO BE EXTENDED
TO DISPOSAL AREA
UPSTREAM LIMIT OF FEDERAL PROJECT
SCALE OF FEET
200 0 200 400 600 800 1000 1200
GREEN BAY
KEWAUNEE
TWO RIVERS
MANITOWOC
SHEBOYGAN
PORT WASHINGTON
MILWAUKEE
WISCONSIN
LAKE MICHIGAN
VICINITY MAP
SCALE OF MILES
10 0 10 20 30 40
LEGEND
Area to be Dredged
X 68-2 Bottom Sample Observed
⊗ 68-1 Bottom Sample Retained
CHICAGO PROGRAM OFFICE
CALUMET AREA SURVEILLANCE UNIT
PORT WASHINGTON, WIS. HARBOR
SAMPLING STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois

TABLE 1

FIELD OBSERVATION OF BOTTOM SEDIMENTS
PORT WASHINGTON HARBOR

April 24, 1968

Sta. PWASH 68-1	Depth 22.5 ft. Grey-brown sandy silt, slight sewage odor, sludgeworms.
Sta. PWASH 68-2	Depth 22 ft. Grey-brown sandy silt, slight sewage odor, sludgeworms.
Sta. PWASH 68-3	Depth 22 ft. Grey-brown sand, no odor, sludgeworms.

TABLE 2

RESULTS OF ANALYSIS OF BOTTOM SEDIMENT SAMPLES
COLLECTED IN PORT WASHINGTON HARBOR April 24, 1968

Station	PWASH 68-1
Parameter	mg/kg
% Total Solids	55.6
% Volatile Solids	12.0
COD	66,900
Total Sol. Phosphorus	3.00
Total Phosphorus	8.45
NH_3-N	347
NO_3-N	4.7
Org-N	761
Phenol	1.32
Oil and Grease	1745
Cyanide	0.04
Sulfide	52
Total Iron	7,532
Copper	NF
Cadmium	1.5
Nickel	52
Zinc	31
Lead	41
Chromium (Total)	NF

NF Not detected at sensitivity of test.

All results are reported on a DRY basis.

TABLE 3

RESULTS OF ANALYSIS OF WATER SAMPLES
COLLECTED IN PORT WASHINGTON HARBOR April 24, 1968

Station	PWASH 68-3 mg/l
Parameter	
Suspended Solids	94
Dissolved Solids	188
*Turbidity	41
MBAS	0.12
Chloride	10
Sulfate	34
COD	53
Total Sol. Phosphorus	0.05
Total Phosphorus	0.13
NH_3-N	0.04
NO_3-N	1.3
Org.-N	1.3
Phenol	0.003
Oil and Grease	1.0
Cyanide	NF
Total Iron	2.6
pH	8.4
Temp. °C	9

*Turbidity is expressed in APHA units, equivalent to Jackson units.
NF--None Found

LOCATION OF SAMPLING POINTS

PORT WASHINGTON HARBOR
April 24, 1968

Sta. PWASH 68-1 Mid-channel between coal dock and inner light
Lat. 43°-20'-12"
Long. 87°-52'-03"

Sta. PWASH 68-2 250' from coal dock, 550' from inner light
Lat. 43°-20'-11"
Long. 87°-51'-55"

Sta. PWASH 68-3 400' from south pier light, 950' from breakwater light
Lat. 43°-20'-10"
Long. 87°-51'-47"

APPENDIX A 18

REPORT ON THE DEGREE OF POLLUTION OF BOTTOM
SEDIMENTS IN MANITOWOC HARBOR

April 23, 1968

May 1968

Federal Water Pollution Control Administration
Great Lakes Region
Chicago Program Office

In accordance with an agreement between the Federal Water Pollution Control Administration and the United States Army Corps of Engineers that the Federal Water Pollution Control Administration would determine the degree of pollution of bottom sediments in harbors to be dredged by the Corps of Engineers, personnel of the Chicago Program Office sampled Manitowoc Harbor on April 23, 1968. The points sampled represent areas scheduled for dredging on a map provided by the Corps of Engineers.

Members of the sampling crew were:

Robert J. Bowden - Sanitary Engineer
Joseph V. Slovick - Hydraulic Technician
Daniel Chorowicki - Boat Operator-Sampler
Steven Pardieck - Engineer

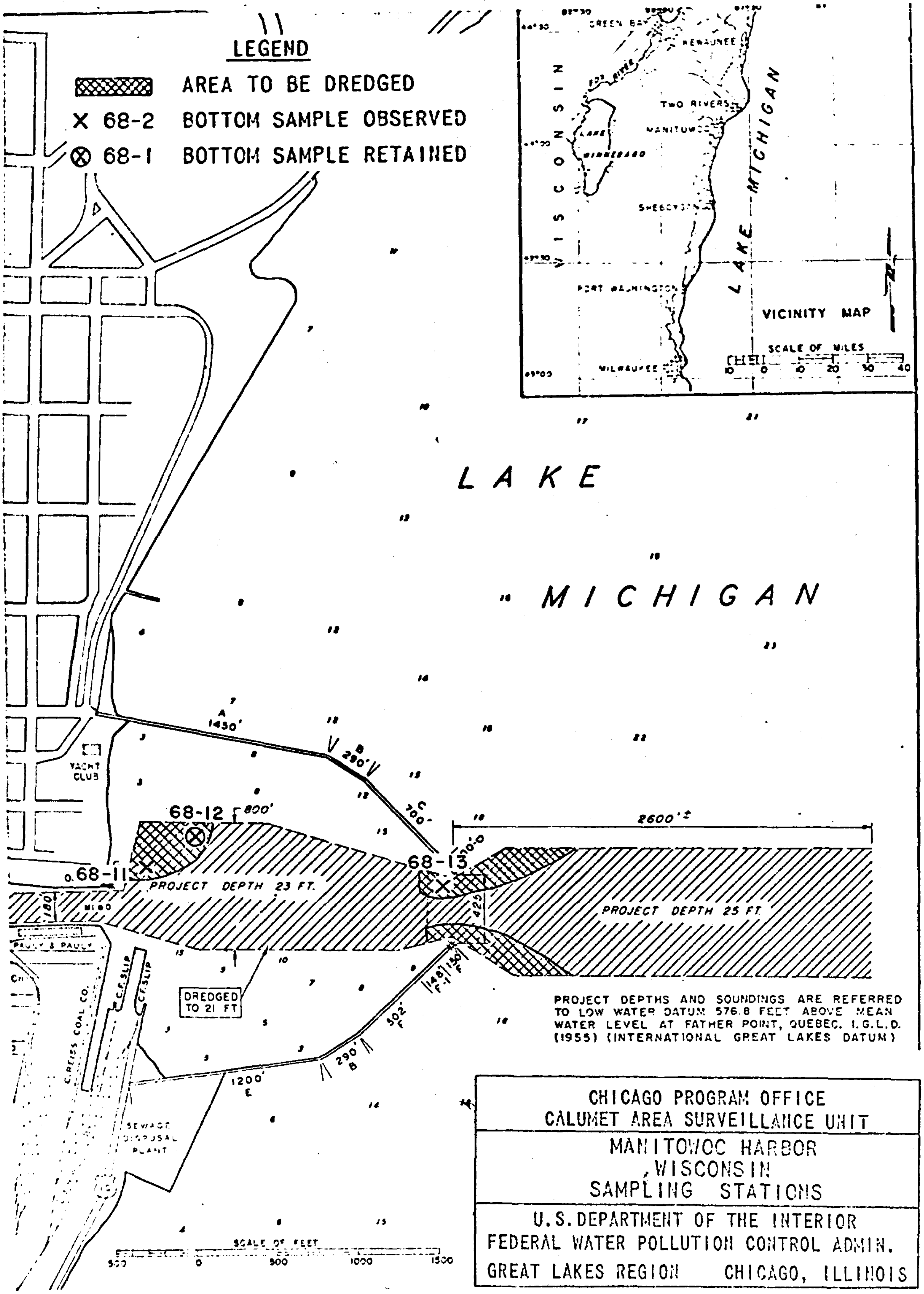
CONCLUSIONS AND RECOMMENDATIONS

1. Bottom sediments in the Manitowoc River upstream of the Eighth Street bridge are polluted and their disposal in Lake Michigan would constitute a significant source of nutrients and other pollutants to the Lake.

2. Bottom sediments in Manitowoc Harbor downstream of the mouth of the river consist primarily of sand. Disposal of this sand in the lake would not constitute a significant source of nutrients.

3. The water being discharged to Lake Michigan from the Manitowoc River did not meet several criteria developed for similar waters. Efforts should be made to reduce the amount of phosphorus discharged to the river.

MANITOWOC
N
NEW YORK
HURON ST.
PARK ST.
CHICAGO ST.
COMMERCIAL ST.
QUAY ST.
JAY ST.
WASHINGTON ST.
MARSHALL ST.
MANITOWOC RIVER
MANITOWOC PORTLAND CEMENT CO.
BURGER BOAT CO.
WIS. PUBLIC SERVICE CORP.
MANITOWOC SHIPBUILDING INC.
FLOATING DRY DOCK
UPSTREAM LIMIT OF FEDERAL PROJECT
CONSUMERS STEEL DOCK CO.
68-1
68-2
68-3
68-4
68-5
68-6
68-7
68-8
68-9
68-10
SOO LINE DOCK
WIS. FUEL & LIGHT CO.
SHELL PETRO CORP.
SINCLAIR REFIN. CO.
AMERICAN OIL CO.
SOO LINE FREIGHT DOCK
DREDGED TO 21 FT
PROJECT DEPTH 21 FT.
C.F. SLIP
DEPOT
WISCONSIN MALTING CO.
C. & N. W. RY.
THE SPINDLER CO.
SPINDLER CO.
ANHEUSER-BU
M. ST. P. & S. STE. M.
C. & N. W.
21 ST.
18 TH.
16 TH.
10 TH.
8TH ST.
U.S. 10 & 141


LEGEND
AREA TO BE DREDGED
X 68-2 BOTTOM SAMPLE OBSERVED
⊗ 68-1 BOTTOM SAMPLE RETAINED
GREEN BAY
KEWAUNEE
TWO RIVERS
MANITOWOC
LAKE WINNEBAGO
SHEBOYGAN
PORT WASHINGTON
MILWAUKEE
WISCONSIN
LAKE MICHIGAN
VICINITY MAP
SCALE OF MILES
10 0 10 20 30 40
LAKE
MICHIGAN
A 1450'
B 290'
C 700'
YACHT CLUB
68-12
800'
68-13
2600'±
68-11
PROJECT DEPTH 23 FT.
PROJECT DEPTH 25 FT.
425'
PAULY & PAULY
C.F. SLIP
C.F. SLIP
C. REISS COAL CO.
DREDGED TO 21 FT
F-1 148'
F 150'
F 502'
B 290'
E 1200'
SEWAGE DISPOSAL PLANT
SCALE OF FEET
500 0 500 1000 1500
PROJECT DEPTHS AND SOUNDINGS ARE REFERRED TO LOW WATER DATUM 576.8 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC. I.G.L.D. (1955) (INTERNATIONAL GREAT LAKES DATUM)
CHICAGO PROGRAM OFFICE
CALUMET AREA SURVEILLANCE UNIT
MANITOWOC HARBOR
, WISCONSIN
SAMPLING STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS

DISCUSSION OF RESULTS

The bottom sediment at Station MANI 68-1 is moderately polluted by both industrial and domestic wastes. The concentrations of cyanide and oil and grease were low but concentrations of iron, phenol, COD, zinc and lead were moderately high and the concentration of sulphite was high when compared with other Wisconsin harbors on Lake Michigan. Phosphorus and nitrogen concentrations were moderately high as was the percentage of volatile solids. This indicates the presence of organic materials from domestic sources (see Table 2). The field observations (Table 1) do not mention the presence of sludgeworms or other benthic organisms. The organic contamination is not bad enough to cause a total destruction of benthic life so that the area is probably subject to high concentrations of toxic metals from industrial sources. The high zinc and lead concentrations confirm this. The field notes indicate that the materials at Stations MANI 68-2 and MANI 68-3 have the same general characteristics (see map, page 3).

The sediments at Station MANI 68-5 are more severely polluted by both industrial and domestic wastes. Concentrations of industrial pollutants (phenol, cyanide, iron and the toxic metals) were only slightly higher but the concentrations of phosphorus, nitrogen and COD were considerably higher at MANI 68-5, indicating considerable domestic pollution. The most probable source of this pollution is combined sewer overflows or direct discharges to the river. The lack of benthic life and the grey-brown color found at stations MANI 68-9 and MANI 68-10 indicate that severely polluted conditions extend at least to the Eighth Street bridge and probably to the mouth.

The sediments at Station MANI 68-12 consisted primarily of brown sand that is prevalent in Lake Michigan on the western shore. The chemical analysis shows that the pollution is much less severe than in the river. Concentrations of phosphorus, oil and grease, cyanide, sulphide, iron and lead are all comparatively low. The presence of sludgeworms at Station MANI 68-11 indicates that benthic life can survive in the area.

It was originally intended to collect more samples near Station MANI 68-13 but rough water prevented this. Station MANI 68-13 was clean sand and it is likely that the entire area to be dredged around the outer harbor mouth consists of clean sand.

A water sample was collected at Station MANI 68-11 to indicate the quality of water being discharged from the Manitowoc River to Lake Michigan. The results were compared to the criteria adopted for inner harbor basins by the Calumet Area Enforcement Conference. These criteria are used for comparison purposes only, they are not officially applicable to Manitowoc Harbor. The maximum criteria for dissolved solids, sulphates and phosphorus were not met. Average criteria for MBAS, ammonia and phenols were not met. This indicates that the Manitowoc River constitutes a moderately severe source of pollution to Lake Michigan. Particularly serious is the concentration of total phosphorus. Efforts should be made to reduce the amount of phosphorus discharged to the stream.

TABLE I

FIELD OBSERVATIONS OF BOTTOM SEDIMENTS
MANITOWOC HARBOR
April 23, 1968

Station MANI 68-1	Depth 17' Sandy silt, grey-brown, some leaves and twigs, no odor.
Station MANI 68-2	Depth 20' Grey-brown sand, some black specks, leaves and twigs, no odor.
Station MANI 68-3	Depth 18.5' Grey-brown silt, cinders, no odor.
Station MANI 68-4	Depth 24' Grey-brown sandy silt, gravel, slight fish odor.
Station MANI 68-5	Depth 20' Grey-brown silt, twigs, no odor.
Station MANI 68-6	Depth 19.5' Grey-brown silt, no odor
Station MANI 68-7	Depth 20.5' Brown silt, some oil, no odor.
Station MANI 68-8	Depth 21' Grey silt, gravel, no odor.
Station MANI 68-9	Depth 16' Grey-brown sand, some twigs, no odor.
Station MANI 68-10	Depth 15' Grey-brown sand, no odor.
Station MANI 68-11	Depth 20' Brown sand, silty black spots, sludgeworms, no odor.
Station MANI 68-12	Depth 21' Brown sand, no odor.
Station MANI 68-13	Depth 24' Sand, no odor.

TABLE 2

RESULTS OF ANALYSES OF BOTTOM SEDIMENT SAMPLES
COLLECTED IN MANITOWOC HARBOR April 23, 1968

Station	MANI-68-1 mg/kg	MANI-68-5 mg/kg	MANI-68-12 mg/kg
Parameter			
% Total Solids	52.3	47.6	48.7
% Volatile Solids	14.6	16.1	11.3
COD	81,800	112,200	105,000
Total Sol. Phosphorus	7.50	30.44	20.73
Total Phosphorus	147	672	54.0
NH_3-N	295	67.6	390
NO_3-N	9.2	9.2	11
Org-N	2,088	2,859	2,690
Phenol	2.84	2.17	2.57
Oil and Grease	1,243	2,897	1,447
Cyanide	0.03	0.08	0.05
Sulfide	80	53	NF
Total Iron	10,720	12,940	6,324
Copper	NF	5.3	NF
Cadmium	1.4	1.5	2.1
Nickel	29	17	NF
Zinc	195	120	90
Lead	53	97	47
Chromium	NF	NF	NF

NF Not detected at sensitivity of test.

All results reported on a DRY basis.

TABLE 3

RESULTS OF ANALYSIS OF WATER SAMPLES
COLLECTED IN MANITOWOC HARBOR April 23, 1968

Station	MANI-68-11 mg/l
Parameter	
Suspended Solids	61
Dissolved Solids	325
*Turbidity	28
MBAS	0.24
Chloride	15
Sulfate	87
COD	275
Total Sol. Phosphorus	0.13
Total Phosphorus	0.37
NH_3-N	0.10
NO_3-N	1.4
Org-N	2.4
Phenol	0.005
Oil and Grease	3.1
Cyanide	NF
Total Iron	3.8
pH	8.2
Temp. °C	10

*Turbidity is expressed in APHA units, equivalent to Jackson units.

NF - None found

LOCATION OF SAMPLING POINTS

MANITOWOC HARBOR
April 23,1968

Sta. MANI 68-1 Manitowoc River - 30 feet from south bank, 300 feet east of Manitowoc Eng. Co. dry dock
Lat. 44^{o}-05'-01"
Long. 87^{o}-39'-53"

Sta. MANI 68-2 Manitowoc River-100 feet from north bank opposite east end of Manitowoc Eng. Co. building
Lat. 44^{o}-06'-01"
Long. 87^{o}-39'-48"

Sta. MANI 68-3 Manitowoc River - 75 feet from south bank, 300 feet upstream from Manitowoc Ship building boat hoist
Lat. 44^{o}-05'-58"
Long. 87^{o}-39'-45"

Sta. MANI 68-4 Manitowoc River - 50 feet from south bank, 250 feet upstream from Soo Line Railroad lift bridge
Lat. 44^{o}-05'-48"
Long. 87^{o}-39'-51"

Sta. MANI 68-5 Manitowoc River - 100 feet from east bulkhead, 250 feet south of Soo Line Railroad lift bridge
Lat. 44^{o}-05'-45"
Long. 87^{o}-39'-57"

Sta. MANI 68-6 Manitowoc River - 100 feet from west bulkhead 150 feet from south bulkhead in corner of turning basin downstream of Soo Line Railroad lift bridge.
Lat. 44^{o}-05'-45"
Long. 87^{o}-40'-02"

Sta. MANI 68-7 Manitowoc River - 75 feet from northeast bulkhead at foot of S. Fourteenth Street
Lat. 44^{o}-05'-41"
Long. 87^{o}-39'-53"

Sta. MANI 68-8 Manitowoc River - 50 feet from southwest bulkhead at foot of South Thirteenth Street
Lat. 44^{o}-05'-35"
Long. 87^{o}-39'-50"

Sta. MANI 68-9 Manitowoc River - 50 feet from north bulkhead at Ninth Street
Lat. 44^{o}-05'-33"
Long. 87^{o}-39'-32"

Location of Sampling Points
(Manitowoc Harbor (Cont'd)

Sta. MANI 68-10 Manitowoc River - 50 feet from south bulkhead at Ninth Street
Lat. 44^{o}-05'-31"
Long. 87^{o}-39'-32"

Sta. MANI 68-11 Manitowoc Harbor - 200 feet east of Pierhead Light
Lat. 44^{o}-05'-33"
Long. 87^{o}-39'-03"

Sta. MANI 68-12 Manitowoc Harbor - 400 feet northeast of Pierhead Light
Lat. 44^{o}-05'-35"
Long. 87^{o}-39'-00"

Sta. MANI 68-13 Manitowoc Harbor - 100 feet south of North Breakwater Light
Lat. 44^{o}-05'-33"
Long. 87^{o}-38'-37"

APPENDIX A 19

FINAL
REPORT ON THE DEGREE OF POLLUTION OF BOTTOM
SEDIMENTS IN TWO RIVERS HARBOR

April 22, 1968

April 1968

Federal Water Pollution Control Administration
Great Lakes Region
Chicago Program Office

In accordance with an agreement between the Federal Water Pollution Control Administration and the United States Army Corps of Engineers that the Federal Water Pollution Control Administration would determine the degree of pollution of bottom sediments in harbors to be dredged by the Corps of Engineers, personnel of the Chicago Program Office sampled Two Rivers Harbor on April 22, 1968. The points sampled represent areas scheduled for dredging on a map provided by the Corps of Engineers.

Members of the sampling crew were:

Robert J. Bowden - Sanitary Engineer
Joseph V. Slovick - Hydraulic Technician
Daniel Chorowicki - Boat Operator-Sampler
Steven Pardieck - Engineer

CONCLUSIONS BASED ON FIELD OBSERVATIONS

1. The bottom sediment in the area near the end of the breakwaters is clean sand.

2. Bottom sediments in the area at the mouth of the East Twin River are not seriously polluted.

FINAL CONCLUSIONS

1. The bottom sediment in the area near the outer end of the breakwater is clean sand.

2. Bottom sediments in the area at the mouth of the East Twin River are seriously polluted and should not be disposed of in Lake Michigan.

3. The water at the mouth of the East Twin River contained significant amounts of pollution, especially nitrogen and phosphorus. Action should be taken to reduce the amount of nutrients discharged to the stream.

Discussion of Field Observations (See Table 1)

The Corps of Engineers dredge "KEWAUNEE" was operating in the area outside of the breakwater lights on April 22, 1968, the day of the bottom sampling. Mr. Wesley LaFever, master of the dredge, indicated that they had been operating since April 6, 1968 as scheduled.

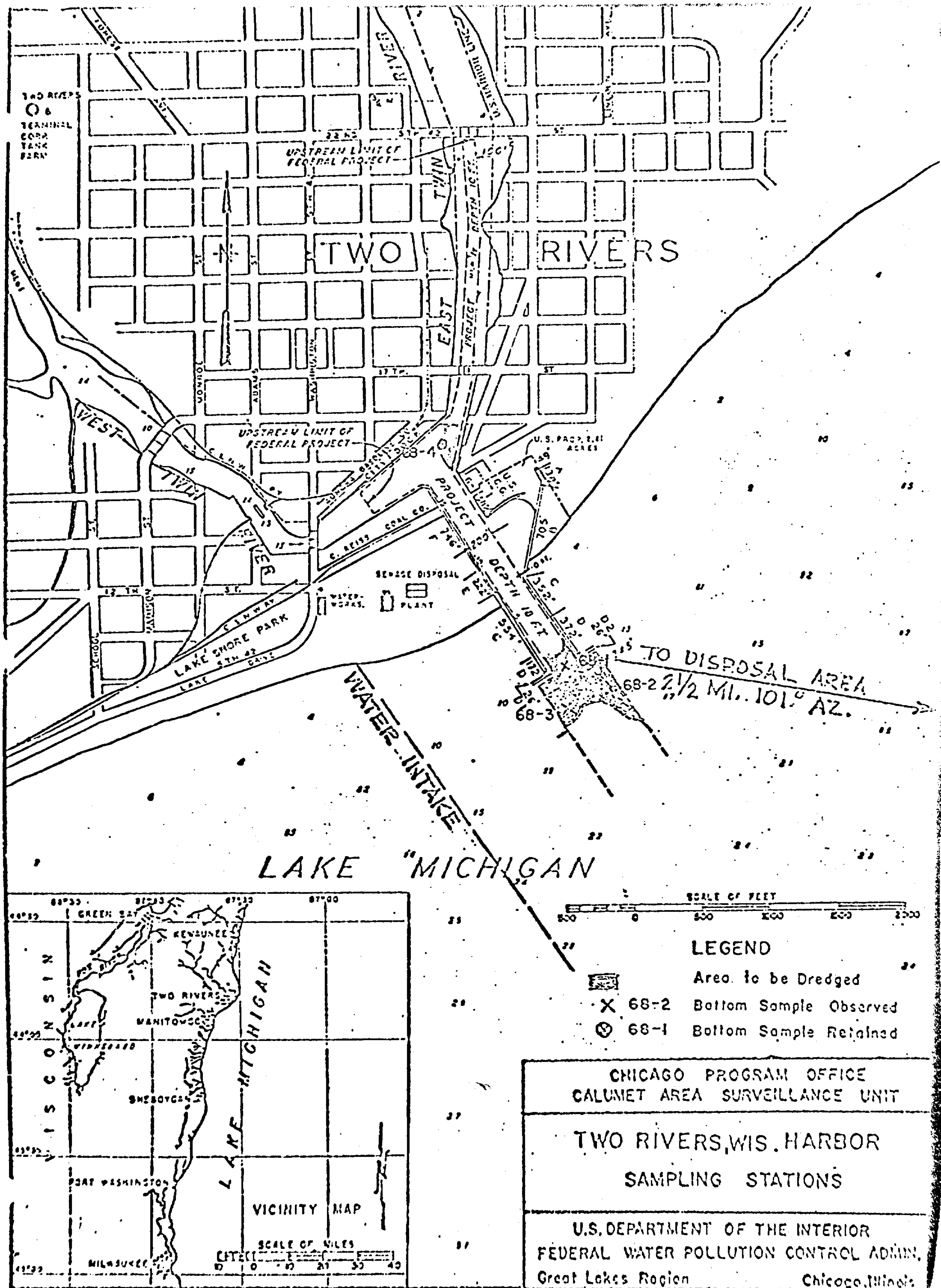
A barge was partially filled with dredged material. All of the material appeared to be clean sand. This agreed with the samples collected at stations TRIV 68-1, TRIV 68-2 and TRIV 68-3 (see table 1).

The sample collected at Sta. TRIV 68-4 was made up of sand with some silt. It did not appear to be severely polluted. (See Page 5)

Mr. LaFever reported that the dredging was about 80% complete and that all of the spoil was sand except for some silt from the inner harbor area. The spoil was disposed of in the disposal area in Lake Michigan.

A water sample was collected at Sta. TRIV 68-4 to indicate the water quality in the harbor. This sample may have been contaminated by red lead paint which was floating on the water. It came from painting on the 16th Street bridge over the East Twin River.

Color photographs of the bottom sediments found at TRIV 68-3 and 68-4 and of the sand in the barges are on file at the Chicago Program Office.



TWO RIVERS
LAKE MICHIGAN
UPSTREAM LIMIT OF FEDERAL PROJECT
UPSTREAM LIMIT OF FEDERAL PROJECT
EAST TWIN
WEST TWIN
PROJECT DEPTH 10 FT.
TO DISPOSAL AREA 2 1/2 MI. 101° AZ.
WATER INTAKE
LAKE SHORE PARK
SEWAGE DISPOSAL PLANT
WATER WORKS
C. REISS COAL CO.
68-1
68-2
68-3
68-4
SCALE OF FEET
500 0 500 1000 1500 2000
LEGEND
Area to be Dredged
X 68-2 Bottom Sample Observed
68-1 Bottom Sample Retained
VICINITY MAP
SCALE OF MILES
10 0 10 20 30 40
GREEN BAY
KEWAUNEE
TWO RIVERS
MANITOWOC
SHEBOYGAN
PORT WASHINGTON
MILWAUKEE
WISCONSIN
LAKE MICHIGAN
LAKE WINNEBAGO
CHICAGO PROGRAM OFFICE
CALUMET AREA SURVEILLANCE UNIT
TWO RIVERS, WIS. HARBOR
SAMPLING STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region
Chicago, Illinois

DISCUSSION OF LABORATORY RESULTS

The laboratory results do not confirm the conclusion taken from field observations that the bottom sediments at Sta. TRIV 68-4 are not seriously polluted. The results (Table 2) show high concentrations of COD, phosphorus, nitrogen, phenol and sulphide and moderately high concentrations of cyanide, iron and oil and grease. This indicates serious pollution from both domestic and industrial sources.

Analysis of the water sample collected at this point also indicates considerable pollution (see Table 3). Maximum inner harbor basin criteria for dissolved solids, total phosphorus and ammonia nitrogen were not met. Sulphate, phenol and MBAS concentrations were dangerously close to the maximum allowable under the criteria and higher than the allowable averages. The criteria are those adopted for inner harbor basins by the Calumet Area Enforcement Conferees and are used for comparison purposes only. They are not officially applicable to Two Rivers Harbor. The COD was also very high although no reasonably applicable criterion has been published for this parameter.

The material in the inner harbor should not be disposed of in Lake Michigan. There is no evidence to indicate that a significant amount of this material reached the dredging area around the pierhead lights. All of the field observations indicated that spoil from that area consisted of sand that drifted into the channel from other parts of Lake Michigan.

LOCATION OF SAMPLING POINTS

TWO RIVERS HARBOR
April 22, 1968

Sta. TRIV 68-1 Mid-channel between North Pierhead Light and South Pierhead Light
Lat. 44°-03'-34"
Long. 87°-33'-39"

Sta. TRIV 68-2 400 feet southeast of North Pierhead Light
Lat. 44°-03'-31"
Long. 87°-33'-35"

Sta. TRIV 68-3 350 feet southeast of South Pierhead Light
Lat. 44°-03'-30"
Long. 87°-33'-39"

Sta. TRIV 68-4 Mouth of East Twin River 150 feet off E. River Street bulkhead
Lat. 44°-03'-50"
Long. 87°-33'-52"

TABLE 1

FIELD OBSERVATIONS OF BOTTOM SEDIMENTS
TWO RIVERS HARBOR
April 22, 1968

Sta.	TRIV 68-1	Depth 18' - no sample after 3 dips.
Sta.	TRIV 68-2	Depth 19' - clean sand some white stones 1/4" dia.
Sta.	TRIV 68-3	Depth 17' - clean sand; no odor.
Sta.	TRIV 68-4	Depth 19' - brown sandy silt; sample retained.

TABLE 2

RESULTS OF ANALYSIS OF BOTTOM SEDIMENT SAMPLES
COLLECTED IN TWO RIVERS HARBOR April 22, 1968

Station	TRIV 68-4 mg/kg
Parameter	
% Total solids	40.3
% Volatile solids	14.6
COD	155,400
Total Sol. Phosphorus	19.83
Total Phosphorus	469
NH_3-N	360
NO_3-N	21
Org-N	5560
Phenol	4.18
Oil and Grease	1,986
Cyanide	0.15
Sulfide	250
Total Iron	9,935
Copper	NF
Cadmium	1.6
Nickel	21
Zinc	238
Lead	62
Chromium	11

NF Not detected within sensitivity of test.
All results reported on a DRY basis.

TABLE 3

RESULTS OF ANALYSIS OF WATER SAMPLES
COLLECTED IN TWO RIVERS HARBOR April 22, 1968

Station	TRIV 68-4 mg/l	Criteria Inner Harbor Basin
Parameter		
Suspended solids	75	
Dissolved Solids	293	max 230
*Turbidity	41	
MBAS	0.26	" 0.30
Chloride	10	" 30
Sulfate	69	" 75
COD	265	
Total Sol. Phosphorus	0.08	
Total Phosphorus	0.17	" 0.03
NH_3-N	0.15	" 0.12
NO_3-N	3.4	
Org-N	1.4	
Phenol	0.005	" 0.005
Oil and Grease	3.4	
Cyanide	NF	" 0.01
Total Iron	3.6	
pH	7.9	7.5-9.0
Temperature °C	10	" 29.4

*Turbidity is expressed in APHA units, equivalent to Jackson units.

NF - None found